UTILIZATION OF SUBMERGED AQUATIC VEGETATION HABITATS BY FISHES AND DECAPODS IN THE GALVESTON BAY ECOSYSTEM, TEXAS

A Thesis

by

ELIZABETH SCOTT

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

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May 1998

Major Subject: Rangeland Ecology and Management

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ABSTRACT

Utilization of Submerged Aquatic Vegetation Habitats by Fishes and Decapods in the Galveston Bay Ecosystem, Texas. (May 1998)

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Fish and decapod densities in shoalgrass, *Halodule wrightii*, wigeongrass, *Ruppia maritima*, and adjacent non-vegetated sand or mud habitats in Galveston Bay, Texas were compared to determine the relative value of each habitat in terms of faunal utilization and species richness. Physical, environmental and other biological variables for each habitat were examined in relation to faunal density. Fish and decapod densities were quantitatively sampled during fall, spring and summer using a $1 m^2$ throw trap. Totals of 48 taxa and 8,163 individuals were collected from 204 m^2 throw trap samples (equally divided between vegetated and non-vegetated habitats) taken during the period 30 September 1993 to 28 November 1994. Vegetated habitat (*Halodule* and *Ruppia)* contained 89% of the total fauna by number (83% decapods; 17% fishes), with non-vegetated substrate (sand and mud) containing 11% (55% decapods; 45% fishes). The dominant species in vegetated habitats were daggerblade grass shrimp, *Palaemonetes pugio*, 40%; blue crab, *Callinectes sapidus*, 15%; and white shrimp, *Penaeus setiferus*, 12%. Dominants in non-vegetated habitats included *Penaeus setiferus*, 21%; *Callinectes sapidus*, 16%; and gulf menhaden, *Brevoortia patronus*, 14%. The amount of submerged aquatic vegetation (SAV) cover appeared to be the most important variable related to total fish and decapod densities. Significant differences in faunal densities indicated that SAV habitat was more valuable to fishes and decapods than non-vegetated substrate. Non-vegetated substrate adjacent to SAV, however, was utilized by some species including commercially important *Penaeus setiferus*. Total faunal densities were similar between *Halodule* and *Ruppia* each season, but there were seasonal variations in use of each habitat at the species level, particularly by some commercial and recreational species. *Halodule* and *Ruppia* appear to function as "essential fishery habitat", as defined by the Magnuson-Stevens Fishery Conservation Act of 1996, and should be conserved to maintain fishery productivity.

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INTRODUCTION

Seagrasses and other salt-tolerant submerged aquatic vegetation (SAV) provide spawning, nursery, protection, and feeding grounds for many commercially and recreationally important species of fishes and decapods, many of which comprise managed and unmanaged coastal and offshore fisheries (Zieman, 1982; Pollard, 1984; Thayer et al., 1984; Thayer and Chester, 1989; Zieman and Zieman, 1989; Kantrud, 1991; Fonseca et al., 1992). Indirect benefits from seagrass habitats to associated fauna and overall health of the environment include sediment stability, erosion control, nutrient cycling, detritus production and water quality indication (Dennison, et al., 1993; La Pointe et al., 1994; Texas Parks and Wildlife Department (TPWD), 1996). Recent amendments to the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) in 1996 and Federal approval of the Texas Coastal Management Plan (TCMP) in 1997 emphasize the importance of coastal and estuarine habitats in maintaining fishery stocks. These amendments provide mandates for identification, conservation and enhancement of marine and estuarine habitats essential for fishery production and survival. Seagrasses and other SAV have been recognized as essential fishery habitats (MSFCMA, 1996).

Despite the importance of these habitats, seagrasses and other salt-tolerant SAV are rapidly declining due to continuing pressures from urban and industrial development. Major bay systems and coastal regions in Florida have experienced seagrass losses of up to 50% (Haddad, 1989). In Florida Bay, massive mortalities of turtlegrass, *Thalassia testudinum*, have occurred since 1987 (Robblee et al., 1991). In Mississippi Sound, a 76% decline in seagrasses has been reported (Eleuterius, 1987). Texas has also lost seagrass acreage. Based on field observations, Adair et al. (1994) reported the greatest

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SAV loss along the upper Texas coast has occurred within the Galveston Bay complex, with a 75% (502 ha to 113 ha) reduction of SAV in Christmas Bay and 100% loss in West Galveston and Bastrop Bays since 1971. Shoalgrass, *Halodule wrightii*, acreage in West Galveston Bay declined from 890 ha in 1956 to 0 ha by 1989 (Pulich and White, 1991; White et al., 1993). Most of the decline in Galveston Bay SAV acreage was attributed to direct and indirect effects of waterfront development through the 1970's, Hurricane Carla in 1961, and subsidence (Pulich and White, 1991). However, other undocumented factors may also account for declines both on local and regional levels (Adair et al., 1994). Coastal erosion, drought, storms, low tides, overgrazing and burrowing by marine organisms, and disease are among the natural processes contributing to natural fluctuations in seagrass coverage (Phillips and McRoy, 1980; Thayer et al., 1984). Dredge and fill or open bay disposal operations, reduction in freshwater inflow, non-point source pollution, nutrient enrichment (eutrophication), and boat propeller scarring have been identified as primary man-made factors reducing water quality and seagrass habitat (Ward and Armstrong, 1992; Galveston Bay National Estuary Program, 1995; TPWD, 1996). Because of the dramatic declines in SAV, resource managers and legislators are concentrating efforts on conserving the remaining SAV and restoring areas that once supported seagrasses (Fonseca, 1994; Galveston Bay National Estuary Program, 1995; TPWD, 1996; Hammerstrom, et al., 1998; Sheridan et al., in press[2]). However, data concerning the relative value of SAV to fish and decapod density and diversity are variable or lacking for many estuaries.

Several researchers report that fish and decapod abundances are substantially higher in seagrass habitats compared to adjacent non-vegetated substrates (Pollard, 1984; Summerson and Peterson, 1984; Fonseca et al., 1990; Thomas et al., 1990; Williams et al., 1989; Sogard and Able, 1991; Humphries et al., 1992; Connolly, 1994a; Sheridan et al., in press[1]). Heck and Orth (1980), however, reported that SAV habitats in lower and upper Chesapeake Bay supported only higher numbers of decapods, but not fishes, than adjacent non-vegetated areas. These researchers suggested that SAV did not serve as important nursery habitat for commercially important fish species, and thus a reduction in SAV biomass should not result in substantial declines in fishery production.

Zimmerman et al. (1990) compared faunal densities among marsh, SAV, and open-water habitats in Galveston Bay in two different salinity regimes. These researchers found that SAV (wigeongrass, *Ruppia maritima;* water nymph, *Najas* sp.; and wild celery, *Vallisneria americana)* use by fishes and decapods was not significantly different from non-vegetated mud in the oligohaline (0.5 to 5 ppt) environment. However, in polyhaline (18 to 30 ppt) waters fish and decapod densities in SAV (primarily *Halodule wrightii* with traces of *Ruppia maritima*, clovergrass, *Halophila engelmannii*, and *Thalassia testudinum)* exceeded those of non-vegetated sand in all seasons. Mesohaline (5 to 18 ppt) SAV habitats were not examined. Thomas et al. (1990) suggested juvenile blue crab, *Callinectes sapidus*, selected for *Halodule wrightii* over non-vegetated sand in Christmas Bay in search of increased food availability and protection from predators. Other than Zimmerman et al. (1990) and Thomas et al. (1990), no other comparative analyses have been published concerning fish and decapod abundances in SAV versus other habitats within Galveston Bay.

The uncertainty on SAV utilization and the minimal amount of data for the Galveston Bay system stimulated this research project. The primary objectives were to compare the relative value of *Halodule, Ruppia* and adjacent non-vegetated sand or mud habitats in terms of fish and decapod density and species richness, and to examine the importance of physical, environmental and other biological variables for each habitat site in relation to faunal density.

MATERIALS AND METHODS

Site Selection

Three areas (six sites) within the Galveston Bay complex (Figure 1) were selected based on the presence and amount of SAV, historical salinity characteristics, depth, and sampling accessibility. Physical and biological characteristics of Galveston Bay were reported by several authors (Sheridan et al., 1988; Zimmerman et al., 1990; Adair et al., 1994; TCMP, 1996). Sediments were classified in accordance with McGowen and Morton (1979) as either sand (predominance of sand over silt and clay) or mud. Sites 1 and 2 consisted of sand (85% sand, 5% silt, 10% clay; P. Sheridan, National Marine Fisheries Service, Galveston, Texas, unpublished data). Site 1 was nonvegetated, while site 2 supported natural beds of primarily *Halodule wrightii*. Both sites 1 and 2 were located in Christmas Bay, adjacent to West Bay. Christmas Bay, while somewhat isolated, is within 5 km of a pass to the Gulf of Mexico, San Luis Pass. Historical salinities in Christmas Bay were in the polyhaline range. Sites 3 and 4 had mud substrates (17% sand, 27% silt, 56% clay; W. Schubert, Texas A&M University at Galveston, Galveston, Texas, unpublished data). Site 3 was non-vegetated, while site 4 contained natural beds of *Ruppia maritima* in isolated patches. Both sites 3 and 4 were located in Highland Bayou Park, part of a 12.5 ha marsh creation project (J. Webb, Texas A&M University at Galveston, Galveston, Texas, pers. commun.), with historical salinities ranging from oligohaline to polyhaline, but averaging mesohaline. Sites 5 and 6 had sandy substrates (77% sand, 13% silt, 12% clay; Whaley, 1997). Site 5 was non-vegetated, while site 6 contained natural beds of *Ruppia maritima*. Historical salinities were polyhaline. Sites 5 and 6 were located at Sportsman Road, along the edge of West Bay. Sportsman Road is influenced by the major pass to the Gulf of Mexico, Bolivar Roads, but is farther from a pass (> 15 km) than Christmas Bay. Highland Bayou Park is not directly influenced by Bolivar Roads, however, it may be affected during periods of low freshwater input from Highland Bayou. The dominant emergent vegetation of adjacent marshes at each of the three areas was smooth cordgrass, *Spartina alterniflora*. *Ruppia* occurred in subtidal pools in approximately 5 m^2 patches at Highland Bayou Park and Sportsman Road, while *Halodule* grew as a uniform band approximately 50 m wide, parallel to the southeast shoreline of Christmas Bay. Sites at Highland Bayou Park and Sportsman Road were located approximately 3 m from emergent vegetation, and Christmas Bay sites were approximately 10 m from salt marsh vegetation.

Sampling Design

Fish and decapod densities were quantitatively sampled at each site using a 1m^2 throw trap (Figure 2; modified from Kushlan, 1981). The throw trap was constructed of 16-gauge aluminum sheeting. The height of the throw trap was 0.5 m. Rozas and Odum (1987) reported catch efficiency (recovery and capture efficiency) between 93% and 100% using a 1m^2 throw trap. Rozas and Minello (1997) highly recommended throw traps over other types of quantitative gear for sampling small fishes and decapods in SAV and non-vegetated substrates.

At each site, vegetated and adjacent non-vegetated areas (< 10 m from vegetation) were selected randomly for faunal sampling. SAV species identification and vegetation cover were recorded at each site prior to faunal sampling (Phillips and McRoy, 1980; Phillips and Meñez, 1988). Percent cover was determined visually (or by touch when turbidity was high) by examining aboveground biomass within the 1m^2 throw sampler. Visual estimates were determined twice, one time each, by two investigators. A 0.5 m^2 quadrat (deployed three times after removal of the throw trap) was used to confirm visual estimates. A total of 204 throw trap samples (equally divided between vegetated and non-vegetated habitats) was taken from 30 September 1993 to 28 November 1994. Samples were collected each month and grouped by season: fall (September, October, November), spring (March, April, May) and summer (June, July, August). *Ruppia* undergoes senescence in late fall and returns in spring, as does abovegound biomass of *Halodule*. Therefore, no samples were collected during winter (December, January, February). Total samples collected were: 72 in fall 1993, 54 in spring 1994, 48 in summer 1994, and 30 in fall 1994. Efforts were made to obtain equal sample sizes among sites during all seasons, but this was not possible due to variations in water levels and in plant cover. Sampling was restricted to periods when water depth was greater than 5 cm (to permit sweeping of the enclosed area) and less than 50 cm (water not exceeding sampler height), and when coverage of SAV exceeded 10% for vegetated areas (vegetated versus non-vegetated comparisons).

Sampling Procedures

Replicate throw trap samples were taken randomly in vegetated and adjacent non-vegetated substrates during daylight. Salinity, temperature, water depth, and dissolved oxygen were measured inside the throw trap using temperature-compensated refractometer, stick thermometer, meter stick, and YSI Model 55 meter, respectively, prior to disturbing the sample. Water samples were taken and returned to the laboratory for turbidity estimates using an HF Scientific Model DRT 100B turbidimeter. Organisms were removed from the trap by sweeping the enclosed area with a 1-m wide aluminum-framed net covered with 1-mm mesh (Figure 2). Preliminary mark recapture experiments indicated that eight sweeps in the trap enclosure (two sweeps from each side of the throw trap) followed by sweeping the throw trap with a dip net constructed of 1-mm webbing for a minimum of 5 minutes (or until no organisms were detected in the dip net) resulted in catch efficiency consistent with Rozas and Odum (1987). Organisms were placed on ice in the field, then transferred and preserved in 10% formalin at the laboratory. Fishes and decapods were sorted, identified, enumerated, and measured (total length for fishes and shrimp; carapace width for crabs). Identification was to the species level or next higher taxon, depending on the size and condition of the specimens, using standard taxonomic keys (Felder, 1973; Hoese and Moore, 1977; U.S. Fish and Wildlife Service, 1978; Heard, 1982; Murdy, 1983; Williams, 1984). Common and scientific names of species are presented in accordance with Robins et al. (1991) and Williams et al. (1989). Mean lengths or widths by habitat were calculated for the most abundant species. Species richness was determined by (S-1)/log n, where S = number of species, and n = number of individuals (Pielou, 1969).

Statistical Analysis

One-way analysis of variance (ANOVA) was used to compare fish and decapod densities among sites during each season. Densities of abundant and commercially important species also were analyzed by the following combinations: (1) grass shrimp - daggerblade grass shrimp, *Palaemonetes pugio,* and marsh grass shrimp, *Palaemonetes vulgaris;* (2) commercial penaeid shrimp - white shrimp, *Penaeus setiferus*, brown shrimp, *Penaeus aztecus,* pink shrimp, *Penaeus duorarum,* and unidentified Penaeidae; and (3) blue crab - *Callinectes sapidus*. Densities of commercial and recreational fishes were too small, even when pooled, to test for significant differences among habitats. Faunal density data were log-transformed to stabilize population variances using a ln(y+1) transformation. The main effect of the one factorial model (site) was further partitioned with *a priori* contrasts (Minello and Webb, 1997) to compare the following: vegetated versus non-vegetated sites, *Halodule* versus *Ruppia,* and mud versus sand substrates. A type I α error of 0.05 or less was used to determine statistical significance. Forward stepwise multiple regression models were used to identify variables that may have accounted for variations in fish and decapod densities among sites. Independent variables (i.e., measurements recorded for each throw trap sample) included: water temperature, salinity, dissolved oxygen, depth, turbidity and SAV cover. Partial F-ratios were set at 4.0 for a variable to be included in the model and 3.996 for removal. Software packages SuperANOVA and StatView (Abacus Concepts, Inc., Berkeley, California, 1991) were used for statistical analyses.

RESULTS

Fish and Decapod Abundance and Distribution

Totals of 48 taxa (43 identifiable to species level) and 8,163 individuals were collected from 204 throw trap samples during the 15-month study period (Table 1). Eight taxa of decapods (7 identifiable species) comprised 80% of the total fauna, with 40 taxa of fishes (36 identified species) accounting for 20%.

Vegetated habitat (*Halodule* and *Ruppia)* contained 89% of the total fauna by number (83% decapods; 17% fishes), with non-vegetated substrate (sand and mud) containing 11% (55% decapods; 45% fishes). The ten most abundant species in vegetated habitats (Figure 3) were *Palaemonetes pugio*, 40%; *Callinectes sapidus*, 15%; *Penaeus setiferus*, 12%; *Penaeus aztecus*, 9%; unidentified Penaeidae, 6%; sheepshead minnow, *Cyprinodon variegatus*, 5%; darter goby, *Gobionellus boleosoma*, 5%; tidewater silverside, *Menidia beryllina*, 1%; bigclaw snapping shrimp, *Alpheus heterochaelis*, 1%; and sailfin molly, *Poecilia latipinna*, 1%. All other species accounted for 5% of the total number of individuals in vegetated habitats. Dominants in non-vegetated habitats (Figure 4) included *Penaeus setiferus*, 21%; *Callinectes sapidus*, 16%; gulf menhaden, *Brevoortia patronus*, 14%; *Menidia beryllina*, 11%; *Palaemonetes pugio*, 7%; *Cyprinodon variegatus*, 7%; unidentified Penaeidae, 6%; herring, Clupeidae, 4%; *Penaeus aztecus*, 4%; and *Gobionellus boleosoma*, 2%. Other species accounted for 7% of the total fauna in non-vegetated habitats.

In *Halodule* 3,752 individuals were collected during the 15-month period (Table 2). Eight taxa of decapods accounted for 86% of the total fauna in *Halodule*. Numerically dominant decapods (accounting for $\geq$ 5% of total decapods) were *Palaemonetes pugio*, 50%; *Callinectes sapidus*, 20%; *Penaeus aztecus*, 13%; unidentified Penaeidae, 10%; and *Penaeus setiferus*, 6%. The remaining three species accounted for

1% of total decapods in *Halodule*. Twenty-three taxa of fishes made up 14% of the total abundance in *Halodule*. Numerical dominants included *Gobionellus boleosoma*, 49%; *Menidia beryllina*, 13%; blackcheek tonguefish, *Symphurus plagiusa,* 8%; and pinfish, *Lagodon rhomboides,* 8%. All other fish taxa accounted for 22%.

Ruppia collections yielded 3,508 individuals during the study period (Table 2). Seven taxa of decapods accounted for 79% of the total faunal abundance in *Ruppia*. Numerically dominant decapods included *Palaemonetes pugio,* 46%; *Penaeus setiferus*, 24%; *Callinectes sapidus*, 17%; and *Penaeus aztecus*, 7%. Twenty-three taxa of fishes comprised 21% of the total number of individuals collected in *Ruppia*. The dominant fish species were *Cyprinodon variegatus*, 54%; *Gobionellus boleosoma*, 10%; *Poecilia latipinna,* 7%; and bayou killifish, *Fundulus pulvereus,* 5%.

A total of 596 individuals was collected over non-vegetated sand substrate during the 15-month period (Table 3). Seven taxa of decapods comprised 63% of the total faunal abundance over sand. Numerical dominants included *Penaeus setiferus*, 34%; *Callinectes sapidus*, 29%; unidentified Penaeidae, 15%; *Palaemonetes pugio*, 14%; and *Penaeus aztecus*, 7%. Twenty taxa of fishes comprised 37% of the total individuals over sand. The dominants were *Cyprinodon variegatus*, 25%; *Menidia beryllina*, 24%; Clupeidae, 18%; and *Gobionellus boleosoma*, 10%.

Over non-vegetated mud, 307 individuals were collected during the 15-month period (Table 3). Fishes dominated over mud and accounted for 62% of the total faunal abundance over this substrate. Thirteen fish taxa were collected over mud. The two dominants (accounting for $\geq$ 5% of total fishes) were *Brevoortia patronus*, 61%; and *Menidia beryllina*, 25%. All other fish taxa made up the remaining 14% of fish abundance. Four decapods species composed 38% of the total fauna over mud. These included *Penaeus setiferus*, 53%; *Callinectes sapidus*, 33%; *Palaemonetes pugio,* 9%; and *Penaeus aztecus*, 5%.

Mean densities of total fishes and decapods from highest to lowest were fall 1993, fall 1994, spring 1994 and summer 1994. The overall distribution of total fish and decapod density by season and site is presented in Figure 5. In any given season, total densities were usually highest at sites 2, 4, and 6 (vegetated) and lowest at sites 1, 3, and 5 (non-vegetated). *Halodule* (site 2) consistently had higher mean densities of total fishes and decapods than other sites during every season with 117.4 individuals/m^2 in fall 1993, 137.9 individuals/m^2 in spring 1994, 61.0 individuals/m^2 in summer 1994, and 122.7 individuals/m^2 in fall 1994. *Ruppia* (sites 4 and 6) typically had intermediate densities of total fishes and decapods, with mud (site 3) and sand (site 5) having low densities. One exception occurred in fall 1994, with sand (site 5) having a higher abundance than *Ruppia* (site 4). Sand (site 1) had the lowest faunal densities during all seasons, with 3.2 individuals/m^2 in fall 1993, 3.8 individuals/m^2 in spring 1994, 0.5 individuals/m^2 in summer 1994, and 2.3 individuals/m^2 in fall 1994.

Species richness (Figure 6; Tables 4 through 7) for total fishes and decapods was highest in *Halodule* (site 2) in all seasons except summer 1994, when *Ruppia* (site 4) had a slightly higher value. In all seasons, species richness for fishes was lower than for decapods in vegetated sites (2, 4, and 6). This typically was the case for non-vegetated sites (1, 3, and 5), with the exceptions of sites 3 and 5 in spring 1994, and site 3 in fall 1994. Decapod species richness was very similar to total fish and decapod values, again showing *Halodule* (site 2) as the highest.

Fishes comprised 15% of the total fauna in fall 1993, 27% in spring 1994, 30% in summer 1994, and 17% in fall 1994. Four fish species comprised 14% of the total fauna collected (Table 1). These included (1) estuarine residents, *Cyprinodon variegatus*, 6%, and *Gobionellus boleosoma*, 4%; (2) a transient species, *Menidia beryllina*, 2%; and (3) a commercially important species, *Brevoortia patronus*, 2%. *Cyprinodon variegatus*, *Gobionellus boleosoma* and *Menidia beryllina* occurred in all seasons, with *Brevoortia* *patronus* occurring in fall 1993 and in spring 1994 (Table 1). Mean densities of these fishes varied depending on site and season (Tables 4 through 7). *Cyprinodon variegatus* abundance was always highest in *Ruppia*. Site 4 contained 13.8 individuals/m^2 in summer 1994, 10.3 individuals/m^2 in spring 1994, and 6.8 individuals/m^2 in fall 1994. The other site containing *Ruppia*, site 6, had the highest density of *Cyprinodon variegatus* in fall 1993 with 2.9 individuals/m^2. *Cyprinodon variegatus* occurred in lower abundance over sand (site 5) with densities ranging from 0.7 individuals/m^2 in summer 1994 to 3.7 individuals/m^2 in fall 1994. *Cyprinodon variegatus* was not abundant in *Halodule* (site 2), sand (site 1) and mud (site 3) during most seasons. *Gobionellus boleosoma* abundance was highest in *Halodule* (site 2) during all seasons, with mean densities ranging from 6.7 individuals/m^2 in fall 1994 to 10.0 individuals/m^2 in summer 1994. *Gobionellus boleosoma* abundance was lower in *Ruppia* (site 6), ranging from 0.1 individuals/m^2 in spring 1994 to 3.9 individuals/m^2 in fall 1993. Sand (site 5) had densities of $\leq$ 3.0 individuals/m^2 in most seasons. *Gobionellus boleosoma* did not occur in *Ruppia* (site 4), mud (site 3) or sand (site 1) during any season. *Menidia beryllina* mean densities reflected more of a seasonal variation with highest abundance in spring 1994. *Halodule* (site 2) contained the highest abundance with 7.6 individuals/m^2, followed by mud (site 3) with 7.3 individuals/m^2, and sand (site 5) with 3.3 individuals/m^2. For all other seasons and sites mean densities were equal to or below 1.1 individuals/m^2. Mean densities of *Brevoortia patronus* were highest over mud (site 3) with 8.3 individuals/m^2 in spring 1994, and 7.3 individuals/m^2 in fall 1993. *Ruppia* (site 4) had *Brevoortia patronus* densities of 1.0 and 1.9 individuals/m^2 for spring 1994 and fall 1993, respectively. The only other occurrence of *Brevoortia patronus* was over sand (site 1) with 0.8 individuals/m^2 for spring 1994.

Mean densities of recreational and other commercial fish species were low. Based on total number of individuals collected (Table 1), 13 red drum, *Sciaenops ocellatus*, were collected during fall 1993 and in spring and fall 1994, over sand (sites 1 and 5), in *Halodule* (site 2) and in *Ruppia* (site 6). Thirteen spot, *Leiostomus xanthurus,* were collected in spring 1994, occurring at all sites except over mud (site 3). Seven sheepshead, *Archosargus probatocephalus,* were collected in spring and summer 1994 in *Halodule* (site 2). A total of seven black drum, *Pogonias cromis,* was collected during the same seasons as *Archosargus probatocephalus,* both over sand (site 5) and in *Ruppia* (site 6). Six Atlantic croaker, *Micropogonias undulatus,* were collected in fall 1993 and spring 1994 in *Halodule* (site 2). Five spotted seatrout, *Cynoscion nebulous,* were collected in fall 1993 and in spring and summer 1994 in *Halodule* (site 2). Leptocephalus larvae of three lady fish, *Elops saurus,* were collected in spring 1994 over sand (site 5). One southern flounder, *Paralichthys lethostigma,* was collected in spring 1994 in *Halodule* (site 2). Fish lengths were variable, and captures were often made at only one of the six sites; therefore, no size comparisons were made.

Decapod crustaceans dominated the total fauna in every season (85% in fall 1993, 73% in spring, 70% in summer, and 83% in fall 1994). Four decapod species comprised 72% of the total fauna. These included the resident *Palaemonetes pugio,* 36%; and three commercially important species, *Callinectes sapidus,* 15%; *Penaeus setiferus,* 13%; and *Penaeus aztecus,* 8%. These four species occurred at most sites in all seasons, but mean densities varied substantially depending on site and season (Tables 4 through 7). By site, mean abundance for *Palaemonetes pugio* was greatest in *Halodule* (site 2) during all seasons with 35.4 individuals/m^2 in fall 1993, 79.1 individuals/m^2 in spring 1994, 20.7 individuals/m^2 in summer 1994, and 60.8 individuals/m^2 in fall 1994. Mean densities of *Palaemonetes pugio* in *Ruppia* (site 6) ranged from 18.7 individuals/m^2 in summer 1994 to 23.9 individuals/m^2 in fall 1993. *Ruppia* (site 4) had *Palaemonetes pugio* densities ranging from 9.8 individuals/m^2 in fall 1994 to 16.6 individuals/m^2 in both fall 1993 and summer 1994. Mean densities of *Palaemonetes pugio* were equal to or less than 1.0

individuals/m^2 for non-vegetated sites during all seasons, with the exception of sand (site 5) in fall 1994 with 12.0 individuals/m^2. *Callinectes sapidus* occurred at all sites during all seasons, however, mean densities varied. Mean densities were highest in *Halodule* (site 2) in fall 1993 (34.5 individuals/m^2), in spring 1994 (6.7 individuals/m^2), and in fall 1994 (19.8 individuals/m^2), with *Ruppia* (site 4) having the highest density in summer 1994 (11.1 individuals/m^2). Mean densities of *Callinectes sapidus* were typically lowest in non-vegetated sites, ranging from 0.2 individuals/m^2 over sand (site 1) in summer 1994 to 4.7 individuals/m^2 over sand (site 5) in fall 1994. *Penaeus aztecus* abundance was greatest in *Ruppia* (site 4) in fall 1993 with 15.1 individuals/m^2. During all other seasons, *Penaeus aztecus* mean densities were highest in *Halodule* (site 2), and ranged from 4.2 individuals/m^2 in fall 1994 to 27.9 individuals/m^2 in spring 1994. *Penaeus aztecus* rarely occurred over sand and mud (sites 1, 3, and 5) with densities ranging from 0.0 to 1.3 individuals/m^2. Mean densities of *Penaeus setiferus* were highest in *Ruppia* (site 4) in fall 1993 (39.7 individuals/m^2), in *Halodule* (site 2) in spring 1994 (2.9 individuals/m^2), in *Ruppia* (site 6) in summer 1994 (4.1 individuals/m^2), and over sand (site 5) in fall 1994 (22.7 individuals/m^2). *Penaeus setiferus* abundance was lowest at all sites in spring 1994 and highest in fall 1993. Mean sizes of the four dominants are presented by site and season in Figure 7. Mean sizes were variable among sites, but generally smaller at *Halodule* (site 2) for all species during all seasons. Larger individuals of *Penaeus setiferus* and *Penaeus aztecus* typically occurred over sand (sites 1 and 6), and larger *Callinectes sapidus* were found over mud (site 3).

Mean densities of fishes and decapods during fall 1993 are presented in Table 4. Fishes with densities > 0.5 individuals/m^2 are shown in Figure 8. The dominant fish species, *Gobionellus boleosoma,* occurred primarily in *Halodule* (site 2) with 7.3 fishes/m^2, followed by *Ruppia* (site 6) with 3.9 fishes/m^2, and sand (site 5) with 0.7 fishes/m^2. *Brevoortia patronus* was dominant over mud (site 3) with 7.3 fishes/m^2, and in *Ruppia* (site 4) with 1.9 fishes/m^2. *Cyprinodon variegatus* occurred in *Ruppia* with 2.9 fishes/m^2 at site 6, and 2.2 fishes/m^2 at site 4. *Cyprinodon variegatus* was less abundant over sand (site 5) with 1.8 fishes/m^2. Other species, listed by site, with mean densities > 0.5 fishes/m^2 included *Symphurus plagiusa,* gulf pipefish, *Syngnathus scovelli,* code goby *Gobiosoma robustum,* and *Sciaenops ocellatus* in *Halodule* (site 2); rainwater killifish, *Lucania parva,* in *Ruppia* (sites 4 and 6); naked goby, *Gobiosoma bosc,* and bay anchovy, *Anchoa mitchilli,* in *Ruppia* (site 4), gulf killifish, *Fundulus grandis,* and *Poecilia latipinna,* in *Ruppia* (site 6); and goby, Gobiidae over mud (site 3). The most abundant decapod species (Figure 9) was *Palaemonetes pugio. Halodule* (site 2) had the highest density of *Palaemonetes pugio* with 35.4 individuals/m^2, followed by *Ruppia* with 23.9 individuals/m^2 at site 6, and 16.6 individuals/m^2 at site 4. *Palaemonetes pugio* densities over non-vegetated sites (1, 3, and 5) were 0.3 individuals/m^2. Commercially important *Callinectes sapidus* was second in abundance with *Halodule* having the highest abundance with 34.5 individuals/m^2. *Ruppia* contained 17.4 individuals/m^2 (site 4), and 8.3 individuals/m^2 (site 6). *Callinectes sapidus* mean abundance was less than or equal to 3.3 individuals/m^2 over non-vegetated sites (1, 3, and 5). *Ruppia* (site 4) had the highest density of *Penaeus setiferus* with 39.7 individuals/m^2. *Halodule* (site 2) and *Ruppia* (site 6) had nearly equal abundances of *Penaeus setiferus* with approximately 8.0 individuals/m^2. Mean densities over mud were 5.0 individuals/m^2, with sand (sites 1 and 5) having less than or equal to 2.3 individuals/m^2. *Penaeus aztecus* abundance was highest in *Ruppia* (site 4) with 15.1 individuals/m^2, followed by *Halodule* (site 2) with 6.8 individuals/m^2, and *Ruppia* (site 6) with 2.5 individuals/m^2. Mean densities in non-vegetated sites ranged from 0.1 individuals/m^2 over sand (sites 1 and 5) to 0.7 individuals/m^2 over mud (site 3). Unidentified Penaeidae abundance was highest in *Halodule* with 17.8 individuals/m^2. Unidentified Penaeidae mean densities were 1.9 individuals/m^2 in *Ruppia* (site 6), and 0.1

individuals/m^2 over sand (sites 1 and 5). *Alpheus heterochaelis* occurred in *Ruppia* (site 6) with 4.3 individuals/m^2, in lower density in *Halodule* (site 2) with 0.6 individuals/m^2, and in *Ruppia* (site 4) with 0.1 individuals/m^2. Mean densities of *Penaeus duorarum* (sites 1, 2, and 6) and *Palaemonetes vulgaris* (site 2) were 0.1 individuals/m^2.

Mean densities of fishes and decapods during spring 1994 are presented in Table 5. Fishes with densities > 0.5 individuals/m^2 are shown in Figure 10. The dominant fish species, *Menidia beryllina,* occurred primarily in *Halodule* (site 2) with 7.6 fishes/m^2, and over mud (site 3) with 7.3 fishes/m^2. *Menidia beryllina* occurred in lower density over sand (site 5) with 3.3 fishes/m^2, and in *Ruppia* (site 4) with 1.0 fishes/m^2. The remaining two sites, sand (site 1) and *Ruppia* (site 6), had *Menidia beryllina* mean densities of less than 0.5 individuals/m^2. *Cyprinodon variegatus* was abundant in *Ruppia* with 10.3 fishes/m^2 at site 4, and 2.8 fishes/m^2 at site 6. *Cyprinodon variegatus* occurred in lower density over sand (site 5) with 0.8 fishes/m^2. *Cyprinodon variegatus* did not occur in *Halodule* (site 2), sand (site 1) or mud (site 3). *Brevoortia patronus* was dominant over mud (site 3) with 8.3 fishes/m^2. *Brevoortia patronus* occurred in *Ruppia* (site 4) with 1.0 fishes/m^2, and over sand (site 1) with 0.8 fishes/m^2. *Gobionellus boleosoma* was found in *Halodule* (site 2) with 8.0 fishes/m^2. The only other site containing this species was *Ruppia* (site 6) with 0.1 fishes/m^2. *Lagodon rhomboides* densities were highest in *Halodule* (site 2) with 3.0 fishes/m^2, with 0.6 fishes/m^2 in *Ruppia* (site 6). Clupeidae was found only over sand (site 5) with 3.3 fishes/m^2. Other fish species that had mean densities > 0.5 individuals/site included striped mullet, *Mugil cephalus*, in *Ruppia* (site 4) and over mud (site 3), *Leiostomus xanthurus* in *Ruppia* (site 4) and over sand (site 1), with *Archosargus probatocephalus* and *Symphurus plagiusa* in *Halodule* (site 2). The dominant decapod (Figure 11) was *Palaemonetes pugio* with abundance patterns among sites similar to fall 1993. *Halodule* (site 2) had the highest density of *Palaemonetes pugio* with 79.1 individuals/m^2, followed by *Ruppia* with 21.1 individuals/m^2 at site 6, and 13.3 individuals/m^2 at site 4. *Palaemonetes pugio* densities over non-vegetated sites (1, 3, and 5) were equal to or less than 0.1 individuals/m^2. *Penaeus aztecus* was second highest in abundance during this season with *Halodule* (site 2) having the highest density (27.9 individuals/m^2). *Penaeus aztecus* was found in much lower densities in *Ruppia* (site 6) with 1.6 individuals/m^2, and over sand (sites 1 and 5) with densities less than or equal to 1.3 individuals/m^2. *Callinectes sapidus* occurred in all sites but clearly was most abundant in *Halodule* (site 2) with 6.7 individuals/m^2. *Penaeus setiferus* occurred in *Halodule* (site 2) with 2.9 individuals/m^2, and in *Ruppia* (site 6) with 0.3 individuals/m^2.

Mean densities of fishes and decapods during summer 1994 are presented in Table 6. The dominant fish species *Cyprinodon variegatus* occurred in highest abundance in *Ruppia* with 13.8 fishes/m^2 at site 4, and 6.7 fishes/m^2 at site 6. *Cyprinodon variegatus* occurred in lower mean densities over sand (site 5) with 0.7 fishes/m^2, and over mud (site 3) with 0.1 fishes/m^2. *Gobionellus boleosoma* occurred with greatest abundance in *Halodule* with 10.0 fishes/m^2, in lower average numbers in *Ruppia* (site 6) with 0.6 fishes/m^2, and over sand (site 5) with 0.1 fishes/m^2. *Fundulus pulvereus* occurred exclusively in *Ruppia* with 2.3 fishes/m^2 at site 4, and 1.8 fishes/m^2 at site 6. *Menidia beryllina* was most abundant in *Ruppia* (site 4) with 1.1 fishes/m^2, in lower densities over sand (site 5) with 1.0 fishes/m^2, and over mud (site 3) with 0.1 fishes/m^2. *Lagodon rhomboides* occurred exclusively in *Halodule* (site 2) with 2.0 fishes/m^2. Other fish species with mean densities > 0.5 individuals/m^2 (Figure 12) included diamond killifish, *Adinia xenica*; longnose killifish, *Fundulus similis*; and *Lucania parva* in *Ruppia* (site 6). As in the previous seasons, the dominant decapod (Figure 13) was *Palaemonetes pugio* (sites 2, 4, and 6). *Callinectes sapidus* was second highest in abundance, and again were present at all sites, but most abundant in *Ruppia* (site 4) with 11.1 individuals/m^2, followed by *Halodule* (site 2) with 8.3 individuals/m^2, and Ruppia (site 6) with 4.7 individuals/m^2. Commercially important shrimp *Penaeus setiferus, Penaeus aztecus* and unidentified Penaeidae occurred in similar densities, with *Penaeus setiferus* most abundant in *Ruppia* (site 6) with 4.1 individuals/m^2. Mean densities of *Penaeus aztecus* and unidentified Penaeidae were highest in *Halodule* (site 2) with 9.2 and 7.0 individuals/m^2, respectively.

Mean densities of fishes and decapods during fall 1994 are presented in Table 7. As in spring and summer 1994, the two dominant fish species were *Cyprinodon variegatus* and *Gobionellus boleosoma* (Figure 14). *Cyprinodon variegatus* was dominant in *Ruppia* with 6.8 fishes/m^2 at site 4, and 5.7 fishes/m^2 at site 6. *Cyprinodon variegatus* occurred over sand (site 5) with 3.7 fishes/m^2, and mud (site 3) with 1.0 fishes/m^2. *Gobionellus boleosoma* occurred with greatest abundance in *Halodule* (site 2) with 6.7 fishes/m^2, in lower density over sand (site 5) with 3.0 fishes/m^2, and in *Ruppia* (site 6) with 2.3 fishes/m^2. *Poecilia latipinna* occurred exclusively in *Ruppia* (site 4) with 5.8 fishes/m^2. *Gobiosoma robustum* occurred primarily in *Halodule* (site 2) with 2.2 fishes/m^2, to a lesser degree over sand (site 5) with 1.3 fishes/m^2, and in still lower abundance in *Ruppia* (site 6) with 0.3 fishes m^2. *Symphurus plagiusa* occurred in *Halodule* with 2.0 fishes/m^2, in lower density in *Ruppia* (site 6) with 0.7 fishes/m^2, and over sand (site 5) with 0.3 fishes/m^2. *Menidia beryllina* was equally abundant in *Ruppia* (site 4) and sand (site 5) with 0.7 fishes/m^2, as well as equally abundant in *Ruppia* (site 6) and mud (site 3) with 0.3 fishes/m^2. *Syngnathus scovelli* occurred only in *Halodule* (site 2) with 1.3 fishes/m^2. *Adinia xenica* was found only over sand (site 5) with 0.7 fishes/m^2. As in all other seasons, the dominant decapod was *Palaemonetes pugio* showing highest abundance at site 2, followed by sites 6 and 4. In this season, however, *Palaemonetes pugio* was abundant not only in vegetated sites but also over sand (site 5; Figure 15). Similarly, *Penaeus setiferus*, the second highest in abundance, occurred in highest density over sand (site 5) with 22.7 individuals/m^2, and in lower densities in *Ruppia* (site 6) with 20.7 individuals/m^2, *Halodule* (site 2) with 12.8 individuals/m^2, *Ruppia* (site 4) with 9.2 individuals/m^2, mud (site 3) with 0.8 individuals/m^2, and sand (site 1) with 0.2 individuals/m^2. Unidentified Penaeidae was most abundant in sand (site 5) with 15.3 individuals/m^2, in *Ruppia* (site 6) with 14.7 individuals/m^2, and *Halodule* (site 2) with 11.3 individuals/m^2. *Callinectes sapidus*, as in other seasons, occurred in all sites, but clearly was most abundant in *Halodule* (site 2) with 19.8 individuals/m^2. *Penaeus aztecus* occurred in much lower density as compared to other seasons, but like other seasons, was found mainly in *Halodule* (site 2), with 4.2 individuals/m^2. As in fall 1994, *Alpheus heterochaelis* occurred in *Ruppia* (site 6) with 1.7 individuals/m^2, and in lower densities ($\leq$ 0.3 individuals/m^2) over sand (sites 1 and 5), and in *Halodule* (site 2).

Statistical Analysis - ANOVA with Contrasts

Mean densities of total fishes and decapods were significantly higher in vegetated sites as compared to non-vegetated sites during every season (Table 8). In fall 1993 total faunal densities in vegetated sites were 9.8 times higher than in non-vegetated sites (Figure 16). In 1994, total fish and decapod densities were 6.7, 13.3, and 5.1 times higher in vegetated sites as compared to non-vegetated sites for spring, summer and fall, respectively (Figures 17 through 19).

Total fish and decapod densities were not significantly affected by SAV type (*Halodule* vs. *Ruppia*; Table 8) in fall 1993 (Figure 16) or in summer 1994 (Figure 18). There were significant differences, however, in total fish and decapod densities between *Halodule* and *Ruppia* in spring (Figure 17) and fall 1994 (Figure 19). In spring 1994, *Halodule* samples had 4.3 times higher mean densities of grass shrimp, 25.7 times higher densities of commercial shrimp, primarily *Penaeus aztecus* (Table 5), and 9.3 times higher densities of blue crabs. In fall 1994, small but significantly higher densities of grass shrimp and blue crab in *Halodule* accounted for the difference. Total fish and decapod densities (Figures 16 through 19) in non-vegetated substrate (sand vs. mud) were not significantly different, with the exception of fall 1994 when higher densities of *Penaeus setiferus* occurred over sand bottom.

Mean fish densities were significantly higher in vegetated sites as compared to non-vegetated sites during every season (Table 8). Fish densities were not significantly affected by SAV type (*Halodule* vs. *Ruppia)* or non-vegetated substrate type (sand vs. mud) during any season (Figures 20 through 23).

Mean densities of all decapods were significantly higher in vegetated sites as compared to non-vegetated sites during all sampling periods (Table 8; Figures 24 through 27). SAV type (*Halodule* vs. *Ruppia)* led to significant differences during spring 1994 and fall 1994, for the reasons listed above. Decapod densities (Figures 20 through 23) were not significantly affected by substrate type (sand vs. mud), with the exception of fall 1994 (higher densities of *Penaeus setiferus* over sand).

Selection of SAV type by commercial shrimp, grass shrimp and blue crab varied during the seasons (Figures 27 through 31), and accounted for the significant differences as discussed above for total fishes and decapods. Significant differences occurred in spring and summer 1994 for commercial shrimp, primarily from *Penaeus aztecus*, with greater densities in *Halodule* than in *Ruppia*. Grass shrimp were significantly higher in *Halodule* in spring and fall 1994, with blue crab abundance greater in *Halodule* than *Ruppia* in all seasons except in summer 1994. Commercial shrimp, grass shrimp and blue crab densities were not significantly related to non-vegetated substrate type, with the one exception being fall 1994 for commercial shrimp (*Penaeus setiferus* densities were greater over sand than mud).

Physical, Chemical and Floral Characteristics

A summary of physical, chemical and floral characteristics for the six study sites is presented in Table 9. In fall 1993, mean water temperatures among the sites ranged from 20.5 to 24.9° C. Salinities for Highland Bayou Park (sites 3 and 4) were expected to be mesohaline; however, mean salinities for all sites were polyhaline, ranging from 23.0 to 29.6 ppt. Mean values ranged from 5.4 to 7.5 ppm for dissolved oxygen, and 22.1 to 36.3 cm for depth. Differences in turbidity and SAV cover among the sites were substantially greater. Mean turbidities ranged from 10.0 to 35.1 FTU and were highest at sites 3 and 4. SAV cover ranged from 0 to 99.6% and was highest at site 2.

In spring 1994, the range in mean water temperatures among sites was from 23.9 to 28.5° C. Mean salinities ranged from mesohaline (6.5 ppt) to polyhaline (22.3 ppt), dropping most noticeably at sites 3 and 4. Water was well-oxygenated with mean dissolved oxygen values from 6.9 to 9.1 ppm. Mean depth was similar among sites, ranging from 29.3 to 35.9 cm. As in fall 1993, differences in turbidity and SAV cover among the sites were large. Mean turbidity varied from 10.8 to 45.9 FTU and was again highest at sites 3 and 4. Vegetation cover ranged from 0 to 68.9% and was similar within each group of vegetated or non-vegetated sites.

Mean water temperatures ranged from 29.6 to 32.8° C in summer 1994. Salinities ranged from mesohaline (sites 3 and 4) to polyhaline (all other sites). Dissolved oxygen mean values varied from 5.4 to 9.2 ppm. The widest seasonal variation in water depths was noted in summer, with mean water depths ranging from 18.0 cm (sites 5 and 6) to 46.6 cm (sites 1 and 2). Mean turbidity was lowest (7.8 FTU) at sites 1 and 2, as it was in all seasons. The highest mean turbidity was 29.5 FTU (site 5). Vegetation cover ranged from 0 to 100% and was highest at sites 2 and 4 and lowest at sites 1, 3 and 5.

In fall 1994, mean values among sites ranged from 23.0 to 26.0° C for water temperature, 6.5 to 25.0 ppt for salinity (sites 3 and 4 remained mesohaline), 6.5 to 10.2

ppm for dissolved oxygen, and 14.4 to 33.6 cm for depth (sites 1 and 2 deeper than all other sites). Turbidity and SAV coverage had the greatest range in terms of mean values among sites. Turbidity was lowest at site 1 (8.7 FTU) and greatest at sites 4 through 6 (45.1 to 47.9 FTU). Vegetation cover ranged from 0 to 100%, remaining high at sites 2 and 4 and declining at site 6.

Overall, water temperature, dissolved oxygen and depth did not vary greatly among sites. In most seasons, salinity was low mesohaline at sites 3 and 4 and polyhaline for all other sites. Turbidity was generally lower at sites 1 and 2, with sites 3 and 4 most turbid. Vegetation cover was variable among sites, but always highest at site 2 and always near 0% at sites 1, 3, and 5.

Associations Between Faunal Densities and Environmental and Floral Variables

Regression models were used to examine associations between fish and decapod densities and physical, chemical and floral factors among sites for each season. The most important variable for explaining variations in total fish and decapod density was the amount of SAV coverage which was included in every model (Table 10). For fishes, water depth generally explained portions of the variability in density, while water temperature explained a portion of the variability in commercial shrimp densities. In fall 1994, SAV cover accounted for a major portion of the variability for all species groupings. Other variables, while not as strongly related as SAV cover, were also important in the models and included mean depth, water temperature, salinity, and dissolved oxygen.

DISCUSSION AND CONCLUSIONS

In terms of support for recreational, commercial, and ecologically important fishery species, data from the present study indicated that mean density of total fauna in SAV was significantly greater per-unit-area than in adjacent non-vegetated habitats during all seasons studied. Fishes comprised approximately 20% of the total fauna collected from throw trap samples during the 15-month study period. *Halodule* supported the highest average number of fishes (16/m^2), followed by *Ruppia* (11/m^2), mud (6/m^2), and sand (3/m^2). Decapods dominated total faunal abundance (80%) with *Halodule* containing the highest mean density of decapods (98/m^2), followed by *Ruppia* (40/m^2), sand (5/m^2), and mud (4/m^2). These findings are similar to results other studies conducted in various regions (Pollard, 1984; Summerson and Peterson, 1984; Fonseca et al., 1990; Williams et al., 1989; Sogard and Able, 1991; Humphries et al., 1992; Connolly, 1994a; Sheridan et al., in press[1]). While sampling methodologies differed, these investigators reported substantially higher fish and decapod abundances in seagrass habitats as compared to adjacent non-vegetated habitats. Comparative analyses of fish and decapod abundances in SAV versus other habitats within mesohaline and polyhaline areas of the Galveston Bay conducted by Zimmerman et al. (1990) and Thomas et al. (1990) also indicate significantly higher densities in SAV than in non-vegetated habitats. Zimmerman et al. (1990) found fish densities higher in *Halodule* (approximately 14/m^2) as compared to adjacent sand substrate (approximately 1/m^2), and decapod densities higher in *Halodule* (approximately 63/m^2) than over sand (approximately 4/m^2).

Densities of fishes in *Halodule* and *Ruppia* were not significantly different; however, *Halodule* generally supported more fish species in all seasons. There was no significant difference in fish densities between non-vegetated substrates of sand or mud. Zimmerman et al. (1990) found higher densities of fishes in spring in SAV at Christmas

Bay than in marsh and non-vegetated substrate, with no significant differences in summer and fall between SAV and marsh.

Fish species collected in SAV in this study are similar to species collected by Zimmerman et al. (1990) as well as in seagrass habitats in other areas (North Carolina, Adams, 1976; Virginia, Orth and Heck, 1980; Florida, Sheridan et al., in press[1]). Orth and Heck (1980) reported selection by *Leiostomus xanthurus* and *Anchoa mitchilli* for vegetation. In the present study these species occurred with greater frequency in non-vegetated habitat. Heck and Orth (1980) also reported that SAV habitats in lower and upper Chesapeake Bay supported only higher numbers of decapods, but not fishes, than did adjacent non-vegetated areas. These researchers suggested that SAV did not serve as important nursery habitat for commercially important fish species, and thus a reduction in SAV biomass should not result in substantial declines in fishery production. In the present study, fish densities were always significantly higher in SAV than in non-vegetated substrates. Zimmerman et al. (1990) had similar findings in polyhaline waters, but not in oligohaline habitats where there was no significance difference in fish density between SAV and mud.

Zimmerman et al. (1990) found that game fishes (*Paralichthys lethostigma, Cynoscion nebulosus* and *Sciaenops ocellatus*) were consistently higher in SAV at Christmas Bay as compared to marsh, other SAV sties, and non-vegetated substrates. However, densities were low ($0.3/m^2$ in spring, $0.2/m^2$ in summer and $0.4/m^2$ in fall in SAV), and no game fishes were caught in non-vegetated sites during the same seasons. In the present study, mean densities of most recreational and most commercial fish species were low as well. Chester and Thayer (1990) concluded that the densities of juveniles of *Cynoscion nebulosus* and gray snapper, *Lutjanus griseus*, the two most prized adult sportsfish in Florida Bay, were low regardless of the sampling gear or catch efficiency associated with a gear type. These authors reviewed other studies reporting low commercial and recreational fish densities using a variety of gears (beach seines, otter trawls, roller frames, sled nets, hook and line, explosives, gillnets and throw traps).

Brevoortia patronus, the most important commercial fishery species by weight off Texas, was only abundant over mud where it comprised 38% of the numbers caught in that habitat. *Cyprinodon variegatus* and *Gobionellus boleosoma* comprised 58% of fish abundance in vegetation. While of no commercial or recreational value directly, these two species have ecological importance as food sources (Minello and Zimmerman, 1983; Thayer et al., 1984), particularly for larger recreational fish species.

Decapod density in relation to SAV type was more variable during the seasons. During spring and fall 1994 *Halodule* had higher mean densities of decapods than did *Ruppia*. This is most likely correlated to the amount of SAV available (i.e., percent cover). While the amount of SAV coverage varied among sites and between seasons, *Halodule* cover was generally higher (69 to 100%) than *Ruppia* cover (11 to 83%). Another important consideration may be the proximity of Christmas Bay (i.e., *Halodule* - site 2) to a major pass, in relation to offshore and nearshore spawning and to subsequent immigration and recruitment of postlarvae and juveniles into estuarine areas. This may have accounted for the higher faunal densities and smaller sized decapods found in *Halodule* than elsewhere. Bell et al. (1988) examined differences in abundance, species composition, and species richness of juvenile fish and decapods associated with SAV at different zones along an Australian estuary. They concluded that neither physical complexity of SAV nor temperature and salinity gradients were responsible for variation in abundance or species richness, instead distributions reflected the combined effects of spawning location and nature of the eggs and larvae (i.e., species spawned at sea had greatest abundances near the lower reaches of the estuary near passes).

Mean densities of commercial shrimp were related to immigration patterns of postlarvae which use the estuary as nursery grounds for growth and survival.

Immigration of *Penaeus aztecus* into Galveston Bay occurs primarily in March and April with a minor peak in September (Baxter and Renfro, 1967). Parker (1970) reported *Penaeus aztecus* postlarvae seek marsh habitat upon entering the Galveston Bay system. I found highest densities of *Penaeus aztecus* in spring and intermediate densities in fall. *Penaeus aztecus* migrate back into offshore waters in May and June as subadults. Postlarval *Penaeus setiferus* enter the estuaries primarily in June and September (Baxter and Renfro, 1967). In this study, highest densities were in fall with lowest densities in spring. *Penaeus setiferus*, depending on environmental conditions within the estuaries, migrate to nearshore waters in August and September (Baxter and Renfro, 1967).

Grass shrimp, which are estuarine residents, were the most abundant species in both *Halodule* and *Ruppia* during all seasons. Zimmerman et al. (1990) and Zimmerman and Minello (1984) found selection by *Palaemonetes pugio* for salt marsh vegetation over non-vegetated substrate. Coen et al. (1981) related this attraction to vegetation by *Palaemonetes pugio* to protection against predators.

Blue crabs, an estuarine-dependent species, were abundant in both *Halodule* and *Ruppia* during all seasons. Selection for vegetation over non-vegetated substrate was similar to that of other studies (Zimmerman and Minello, 1984; Thomas et al., 1990; Zimmerman et al., 1990). Blue crabs were significantly higher in *Halodule* than in *Ruppia* in all seasons except summer 1994. Again, selection for *Halodule* may be related to spawning and immigration patterns in proximity to major passes (Rabalais et al., 1995). Heck and Thoman (1984) found that juveniles of blue crab were found only in seagrass habitats in the lower reaches of Chesapeake Bay.

Total decapod densities were relatively low on non-vegetated habitats. On a species level, however, non-vegetated sand appeared to be important to *Penaeus setiferus* as I found high densities there in fall 1994. Zimmerman and Minello (1984) found that *Penaeus setiferus* densities were not significantly different between vegetated and non-vegetated marsh habitat during the seasons that they were most abundant. These researchers concluded that juvenile *Penaeus setiferus* may use marsh vegetation and non-vegetated substrate equally.

Fish and decapod use of SAV rather than non-vegetated substrate is most likely due to increased food availability and protection (Heck and Thoman, 1981; Minello and Zimmerman, 1983; Zimmerman et al., 1990). Larvae and juveniles of most commercial and recreational marine fishery resources in Texas depend on estuarine systems for nursery habitat (Williams, 1965; Hoese and Moore, 1977). These include penaeid shrimp, *Penaeus* spp.; *Callinectes sapidus*; menhaden, *Brevoortia* spp.; seatrout, *Cynoscion* spp.; *Sciaenops ocellatus*; *Paralichthys lethostigma*; *Pogonias cromis*; and *Micropogonias undulatus*. Selection for salt marsh vegetation by postlarval and juvenile *Penaeus aztecus* was observed by Zimmerman et al. (1984) in western Galveston Bay. Gleason and Zimmerman (1984) demonstrated *Penaeus aztecus* selection for salt marsh habitat increased as food sources became more abundant. Thomas et al. (1990) suggested similar reasons for blue crab selection for SAV and salt marsh vegetation over non-vegetated substrates in Christmas Bay and western Galveston Bay, respectively.

The amount of SAV coverage (percent cover) was the most important factor explaining variability in regression models using total fish and decapod density. For fishes, water depth generally explained portions of the variability in density, with water temperature explaining a portion of the variability in commercial shrimp densities. In fall 1994, SAV cover accounted for a major portion of the variability for all species grouping. Other variables, while not as strongly related as SAV cover, were mean depth, water temperature, salinity and/or dissolved oxygen. The difference in variability in fall 1994, as compared to other seasons, may be attributed to smaller sample size (n = 30) taken in this season. Connolly (1994b), in an experiment in a southern Australian estuary, removed seagrass canopy to test the importance of cover to fishes in areas where all other factors were similar with seagrass presence. Fish abundance was lower than in adjacent areas of undisturbed seagrasses, but not as low as non-vegetated sites. Connolly (1994b) concluded that small fishes did not select SAV based on seagrass cover, but instead for increased food availability. Based on his findings, patterns of fish abundance did not provide evidence of seagrass canopy in attracting increased fish abundances compared with non-vegetated areas, but were consistent with the importance of prey availability in the role seagrass plays as habitat for small fishes. Heck and Orth (1980) hypothesized that the cover from predators was the most important aspect of SAV function for mobile invertebrates and small fishes, and that denser vegetation provides more protection from predation than does sparser vegetation. They suggested that there was a threshold density of SAV required before this habitat provided any significant reduction in predation.

Determining the value of a particular habitat type in terms of utilization by fishery species is critical for successful resource management. Important considerations in assessing habitat value include the recreational, commercial and ecological significance of species utilizing the habitat; the acreage and carrying capacity of available habitat; abundance of prey populations; and alternative habitats that could support displaced species or species of equal value.

The legislative authority to manage fishery habitats was promulgated by federal approval of the Texas Coastal Management Plan in 1997, and the Magnuson-Stevens Act as amended October 11, 1996. These mandates provide for the identification, conservation and enhancement of marine and estuarine habitats essential for fishery production and survival. Essential fishery habitats, as defined in section 3(10) of the Magnuson-Stevens Act, are those waters and substrates necessary to fishes for spawning, breeding, feeding or growing to maturity. Fishes are defined therein as "finfish, mollusks, crustaceans, and all other forms of marine animal and plant, other than marine mammals and birds". As directed by Congress, the National Marine Fisheries Service further defined "waters" as aquatic areas and associated abiotic and biotic properties used by fishes. These areas include sediments, geological structures, and associated biological communities including SAV. "Necessary" is defined as habitat required to support a managed species or assemblage at a target protection level, with spawning, breeding, feeding or growing to maturity meaning a species full life cycle. As a result of these amendments to the Magnuson-Stevens Act, federal fishery management plans must now define essential fishery habitat for each species or group of species.

Both SAV and salt marsh acreage have declined in Galveston Bay (17-19% since 1956; Pulich and White, 1991), however, no dramatic declines have been documented in commercial or recreational fishery harvests for Galveston Bay (Galveston Bay National Estuary Program, 1995). The loss of seagrass habitat in Chesapeake Bay (Harris, 1982) and in Florida (Lynne, 1982) have been suggested as reasons for declining blue crab populations in these areas. Thayer et al. (1984) attributed the collapse of the bay scallop, *Argopecten irradians*, fishery in the northeast to the catastrophic decline ("wasting disease") of eelgrass, *Zostera marina*, in the 1930's; large population declines of other commercial and recreational fishery species were not quantitatively documented or detected. One species of waterfowl, Atlantic brant, *Branta bernicla hrota*, which fed almost exclusively on eelgrass, declined dramatically. After the 1950s, the brant population recovered, after which the brant's food preference shifted to *Ruppia* and sea lettuce, *Ulva lactu*ca. During the 1960's and 1970's a shift from heterogeneous seagrass beds of *Halodule wrightii* and *Thalassia testudinum* to monospecific beds of *Thalassia testudinum* was reported by Thayer et al. (1994). Coincident with this shift, Tilmant (1989) reported a decline in recreational fishery landings.

In Galveston Bay, fishes and decapods may utilize alternate habitats, as necessary, at least as long as that carrying capacity of the remaining SAV and salt marsh habitats have not been exceeded. *Ruppia* undergoes senescence in late fall and returns in spring, as does abovegound biomass of *Halodule*. Thayer et al. (1984) reported drastic declines in density, biomass and canopy surface of *Zostera* beds on the Atlantic coast of North America during cold winter months. During this study, the absence of SAV in December, January, February suggested that fishes and decapods were using other types of habitat, most likely the adjacent salt marsh vegetation, *Spartina alterniflora*, the dominant emergent vegetation. Thomas et al. (1990) reported that *Halodule wrightii* was the preferred nursery habitat for juvenile blue crabs in the northwestern Gulf of Mexico, but because of the lack of or minimal amount of *Halodule*, salt marshes (*Spartina alterniflora*) functioned as alternate juvenile blue crab nursery areas. With respect to declining salt marsh habitat, Minello et al. (1994) hypothesized that the process of salt marsh degradation creates patchy areas of vegetation which allows more tidal exchange and greater accessibility to fauna (edge effect) as compared to solid masses of vegetation found in the interior marsh. This in turn provides more marsh surface for use by juvenile fishery organisms and results in temporarily higher fishery productivity. However, when marsh degradation is complete, these areas turn into less productive open-water habitats. Minello et al. (1994) speculated that when this occurs, fishery populations will decrease dramatically.

Loss of marsh habitat may have been offset because *Ruppia* has re-colonized subtidal pools that once supported salt marsh vegetation, primarily *Spartina alterniflora*. Increased coverage and wider distribution of *Ruppia* throughout the Galveston Bay system were observed in 1997 (W. Schubert, Texas A&M University at Galveston, Galveston, Texas, pers. comm.). Therefore, if *Ruppia* supports higher densities of fishes than nonvegetated mud and sand, as documented in the present study, then it stands to reason that *Spartina alterniflora* could be replaced by *Ruppia* without adverse consequences to the fishery species that utilize these habitats.

One method of offsetting habitat loss is transplanting SAV not only to replace SAV but also to compensate for salt marsh degradation (Fonseca, 1994; Hammerstrom, et al., 1998; Sheridan et al., in press[2]). Hammerstrom et al. (1998), reported that transplanted *Ruppia* is an annual and grows back from seeds in the Galveston Bay system. These authors suggest that for future restoration efforts in Galveston Bay *Ruppia* could be used in oligohaline and mesohaline areas, with mixed plantings of *Halodule* and *Ruppia* in polyhaline areas. These authors indicated that since *Ruppia* was faster growing than the perennial *Halodule*, *Ruppia* would provide the initial stability for the transplanted area. Transplants of *Halodule* were suggested for west Galveston Bay, since *Halodule* dominates polyhaline habitats such as Christmas Bay. In fact, transplanting *Halodule* to West Bay has shown signs of success (Sheridan et al., in press[2]).

In conclusion, protection and enhancement of areas that support SAV are important to major commercial and recreational fisheries, as well as to resident species that support these fisheries. Results from this study indicate that SAV habitat is more valuable to fishes and decapods than non-vegetated substrate. Non-vegetated substrate adjacent to SAV, however, appears to be important to some species including commercially important *Penaeus setiferus*. Total faunal densities were similar between *Halodule* and *Ruppia* each season, but there were seasonal variations in use of each habitat at the species level, particularly by some commercial and recreational species. *Halodule* and *Ruppia* appear to function as "essential fishery habitat", as defined by the Magnuson-Stevens Fishery Conservation Act of 1996, and should be conserved to maintain fishery productivity.

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APPENDIX A: TABLES

Table 1. Number and occurrence of fishes and decapods collected from 204 throw trap samples taken during the period 30 September 1993 to 28 November 1994. Dot in column indicates occurrence.

Species/Taxa	Common Name	*Number*	*Vegetated*	*Non-vegetated*	*Fall 93*	*Spring 94*	*Summer 94*	*Fall 94*	*Site 1 - Sand*	*Site 2 - Halodule*	*Site 3 - Mud*	*Site 4 -Ruppia*	*Site 5 - Sand*	*Site 6 - Ruppia*
Palaemonetes pugio	daggerblade grass shrimp	2972	•	•	•	•	•	•	•	•	•	•	•	•
Callinectes sapidus	blue crab	1254	•	•	•	•	•	•	•	•	•	•	•	•
Penaeus setiferus	white shrimp	1058	•	•	•	•	•	•	•	•	•	•	•	•
Penaeus aztecus	brown shrimp	650	•	•	•	•	•	•	•	•	•	•	•	•
Cyprinodon variegatus	sheepshead minnow	467	•	•	•	•	•	•	•	•	•	•	•	•
Penaeidae, unidentified	unidentified penaeid shrimp	464	•	•	•		•	•	•	•		•	•	•
Gobionellus boleosoma	darter goby	352	•	•	•	•	•	•		•			•	•
Menidia beryllina	tidewater silverside	196	•	•	•	•	•	•	•	•	•	•	•	•
Brevoortia patronus	gulf menhaden	146	•	•	•	•			•		•	•		
Alpheus heterochaelis	bigclaw snapping shrimp	84	•	•	•		•	•	•	•		•	•	•
Poecilia latipinna	sailfin molly	51	•		•		•	•				•		•
Symphurus plagiusa	blackcheek tonguefish	51	•	•	•	•	•	•	•	•	•		•	•
Lagodon rhomboides	pinfish	49	•		•	•	•	•		•				•
Clupeidae	herring	39		•		•							•	
Fundulus pulvereus	bayou killifish	39	•				•	•				•		•
Gobiosoma robustum	code goby	33	•	•	•	•	•	•		•	•	•	•	•
Lucania parva	rainwater killifish	32	•	•	•	•	•	•			•	•		•
Syngnathus scovelli	gulf pipefish	26	•		•	•	•	•		•				
Fundulus grandis	gulf killifish	25	•	•	•	•	•			•		•	•	•
Adinia xenica	diamond killifish	18	•	•	•	•	•	•				•	•	•
Gobiidae	goby	17	•	•	•	•		•		•	•	•		•
Mugil cephalus	striped mullet	16	•	•		•	•				•	•	•	
Gobiosoma bosc	naked goby	14	•		•			•		•		•		
Leiostomus xanthurus	spot	13	•	•		•			•	•		•	•	•
Sciaenops ocellatus	red drum	13	•	•	•	•		•	•	•			•	•
Anchoa mitchilli	bay anchovy	11	•	•	•			•	•		•	•		
Fundulus similis	longnose killifish	11	•	•	•	•	•						•	•
Ophidion welshi	crested cusk-eel	8	•		•			•		•				
Archosargus probatocephalus	sheepshead	7	•			•	•			•				
Pogonias cromis	black drum	7	•	•		•	•						•	•
Micropogonias undulatus	Atlantic croaker	6	•		•	•				•				
Cynoscion nebulosus	spotted seatrout	5	•		•	•	•			•				
Fish larvae, unidentified	unidentified fish	4	•	•	•	•				•	•		•	
Cyprinodontidae	killifish	3	•		•		•					•		•
Elops saurus	lady fish	3		•		•							•	
Penaeus duorarum	pink shrimp	3	•	•	•				•	•				•
Eucinostomus argenteus	flagfin mojarra	2	•				•			•				•
Microgobius gulosus	clown goby	2	•	•	•			•			•	•		
Opsanus beta	gulf toadfish	2	•				•	•		•				
Synodus foetens	inshore lizardfish	2		•		•	•		•		•			
Achirus lineatus	lined sole	1		•	•								•	
Citharichthys spilopterus	bay whiff	1	•			•				•				
Dormitator maculatus	fat sleeper	1		•	•						•			
Mugil curema	white mullet	1		•			•						•	
Orthopristis chrysoptera	pigfish	1	•				•			•				
Palaemonetes vulgaris	marsh grass shrimp	1	•		•					•				
Paralichthys lethostigma	southern flounder	1	•			•				•				
Syngnathus louisianae	chain pipefish	1	•		•					•				
	Total No. Individuals	8163	7260	903	3485	2012	1269	1397	88	3752	307	1718	508	1790

Table 2. Fishes and decapods collected in vegetated sites using throw traps from 30 September 1993 to 28 November 1994.

HALODULE

Species/Taxa	Common Name	Number
Palaemonetes pugio	daggerblade grass shrimp	1626
Callinectes sapidus	blue crab	643
Penaeus aztecus	brown shrimp	412
Penaeidae, unidentified	unidentified penaeid shrimp	324
Gobionellus boleosoma	darter goby	260
Penaeus setiferus	white shrimp	208
Menidia beryllina	tidewater silverside	68
Symphurus plagiusa	blackcheek tonguefish	44
Lagodon rhomboides	pinfish	42
Syngnathus scovelli	gulf pipefish	26
Gobiosoma robustum	code goby	24
Alpheus heterochaelis	bigclaw snapping shrimp	11
Sciaenops ocellatus	red drum	10
Ophidion welshi	crested cusk-eel	8
Archosargus probatocephalus	sheepshead	7
Gobiidae	goby	7
Micropogonias undulatus	Atlantic croaker	6
Cynoscion nebulosus	spotted seatrout	5
Gobiosoma bosc	naked goby	5
Cyprinodon variegatus	sheepshead minnow	4
Opsanus beta	gulf toadfish	2
Citharichthys spilopterus	bay whiff	1
Eucinostomus argenteus	flagfin mojarra	1
Fish larvae, unidentified	unidentified fish	1
Fundulus grandis	gulf killifish	1
Leiostomus xanthurus	spot	1
Orthopristis chrysoptera	pigfish	1
Palaemonetes vulgaris	marsh grass shrimp	1
Paralichthys lethostigma	southern flounder	1
Penaeus duorarum	pink shrimp	1
Syngnathus louisianae	chain pipefish	1
	Total No. Individuals	3752
	Throw Trap Samples	33

RUPPIA

Species/Taxa	Common Name	Number
Palaemonetes pugio	daggerblade grass shrimp	1282
Penaeus setiferus	white shrimp	661
Callinectes sapidus	blue crab	463
Cyprinodon variegatus	sheepshead minnow	401
Penaeus aztecus	brown shrimp	206
Penaeidae, unidentified	unidentified penaeid shrimp	82
Alpheus heterochaelis	bigclaw snapping shrimp	71
Gobionellus boleosoma	darter goby	71
Poecilia latipinna	sailfin molly	51
Fundulus pulvereus	bayou killifish	39
Lucania parva	rainwater killifish	31
Menidia beryllina	tidewater silverside	28
Brevoortia patronus	gulf menhaden	23
Fundulus grandis	gulf killifish	22
Adinia xenica	diamond killifish	14
Mugil cephalus	striped mullet	11
Gobiosoma bosc	naked goby	9
Fundulus similis	longnose killifish	8
Lagodon rhomboides	pinfish	7
Anchoa mitchilli	bay anchovy	5
Gobiidae	goby	4
Leiostomus xanthurus	spot	4
Symphurus plagiusa	blackcheek tonguefish	4
Cyprinodontidae	killifish	3
Gobiosoma robustum	code goby	3
Eucinostomus argenteus	flagfin mojarra	1
Microgobius gulosus	clown goby	1
Penaeus duorarum	pink shrimp	1
Pogonias cromis	black drum	1
Sciaenops ocellatus	red drum	1
	Total No. Individuals	3508
	Throw Trap Samples	69

Table 3. Fishes and decapods collected in non-vegetated sites using throw traps from 30 September 1993 to 28 November 1994.

SAND

Species/Taxa	Common Name	Number
Penaeus setiferus	white shrimp	128
Callinectes sapidus	blue crab	110
Penaeidae, unidentified	unidentified penaeid shrimp	58
Cyprinodon variegatus	sheepshead minnow	55
Menidia beryllina	tidewater silverside	53
Palaemonetes pugio	daggerblade grass shrimp	53
Clupeidae	herring	39
Penaeus aztecus	brown shrimp	26
Gobionellus boleosoma	darter goby	21
Leiostomus xanthurus	spot	8
Brevoortia patronus	gulf menhaden	7
Pogonias cromis	black drum	6
Adinia xenica	diamond killifish	4
Gobiosoma robustum	code goby	4
Anchoa mitchilli	bay anchovy	3
Elops saurus	lady fish	3
Fundulus similis	longnose killifish	3
Alpheus heterochaelis	bigclaw snapping shrimp	2
Fish larvae, unidentified	unidentified fish	2
Fundulus grandis	gulf killifish	2
Sciaenops ocellatus	red drum	2
Symphurus plagiusa	blackcheek tonguefish	2
Achirus lineatus	lined sole	1
Mugil cephalus	striped mullet	1
Mugil curema	white mullet	1
Penaeus duorarum	pink shrimp	1
Synodus foetens	inshore lizardfish	1
	Total No. Individuals	596
	Throw Trap Samples	72

MUD

Species/Taxa	Common Name	Number
Brevoortia patronus	gulf menhaden	116
Penaeus setiferus	white shrimp	61
Menidia beryllina	tidewater silverside	47
Callinectes sapidus	blue crab	38
Palaemonetes pugio	daggerblade grass shrimp	11
Cyprinodon variegatus	sheepshead minnow	7
Gobiidae	goby	6
Penaeus aztecus	brown shrimp	6
Mugil cephalus	striped mullet	4
Anchoa mitchilli	bay anchovy	3
Gobiosoma robustum	code goby	2
Dormitator maculatus	fat sleeper	1
Fish larvae, unidentified	unidentified fish	1
Lucania parva	rainwater killifish	1
Microgobius gulosus	clown goby	1
Symphurus plagiusa	blackcheek tonguefish	1
Synodus foetens	inshore lizardfish	1
	Total No. Individuals	307
	Throw Trap Samples	30

Table 4. Mean densities and (in italics) standard errors of fishes and decapods by site from throw trap samples in fall 1993. The number of taxa, individuals and species richness are shown after each major grouping. Decapod lengths or carapace widths are in mm.

	Fall 1993											
	Site 1		Site 2		Site 3		Site 4		Site 5		Site 6	
	Sand (n = 12)		*Halodule* (n = 12)		Mud (n = 9)		*Ruppia* (n = 9)		Sand (n = 15)		*Ruppia* (n = 15)	
Total Fishes and Decapods	**3.2**	*1.0*	**117.4**	*29.1*	**16.7**	*8.1*	**96.9**	*27.7*	**9.1**	*2.2*	**58.7**	*12.6*
Total No. of Taxa	9		22		11		15		12		17	
Total No. of Individuals	38		1409		150		872		136		880	
Species Richness	1.6		3.1		2.2		2.9		2.1		2.9	
Total Fishes	**0.4**	*0.2*	**14.2**	*5.0*	**8.8**	*7.2*	**8.0**	*2.5*	**3.0**	*1.3*	**9.9**	*2.5*
Achirus lineatus	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.1**	*0.1*	**0.0**	*0.0*
Adinia xenica	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.1**	*0.1*	**0.3**	*0.3*
Anchoa mitchilli	**0.0**	*0.0*	**0.0**	*0.0*	**0.3**	*0.3*	**0.6**	*0.6*	**0.0**	*0.0*	**0.0**	*0.0*
Brevoortia patronus	**0.0**	*0.0*	**0.0**	*0.0*	**7.3**	*7.3*	**1.9**	*1.9*	**0.0**	*0.0*	**0.0**	*0.0*
Cynoscion nebulosus	**0.0**	*0.0*	**0.2**	*0.2*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*
Cyprinodon variegatus	**0.2**	*0.2*	**0.3**	*0.2*	**0.0**	*0.0*	**2.2**	*2.2*	**1.8**	*1.1*	**2.9**	*1.1*
Cyprinodontidae	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.1**	*0.1*
Dormitator maculatus	**0.0**	*0.0*	**0.0**	*0.0*	**0.1**	*0.1*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*
Fish larvae, unidentified	**0.0**	*0.0*	**0.1**	*0.1*	**0.1**	*0.1*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*
Fundulus grandis	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.1**	*0.1*	**0.1**	*0.1*	**0.9**	*0.7*
Fundulus similis	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.1**	*0.1*	**0.0**	*0.0*
Gobiidae	**0.0**	*0.0*	**0.3**	*0.2*	**0.7**	*0.7*	**0.3**	*0.3*	**0.0**	*0.0*	**0.1**	*0.1*
Gobionellus boleosoma	**0.0**	*0.0*	**7.3**	*3.3*	**0.0**	*0.0*	**0.0**	*0.0*	**0.7**	*0.3*	**3.9**	*0.9*
Gobiosoma bosc	**0.0**	*0.0*	**0.4**	*0.3*	**0.0**	*0.0*	**0.9**	*0.6*	**0.0**	*0.0*	**0.0**	*0.0*
Gobiosoma robustum	**0.0**	*0.0*	**0.7**	*0.4*	**0.1**	*0.1*	**0.2**	*0.2*	**0.0**	*0.0*	**0.0**	*0.0*
Lagodon rhomboides	**0.0**	*0.0*	**0.2**	*0.1*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*
Lucania parva	**0.0**	*0.0*	**0.0**	*0.0*	**0.1**	*0.1*	**1.4**	*1.0*	**0.0**	*0.0*	**0.6**	*0.4*
Menidia beryllina	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.2**	*0.2*	**0.1**	*0.1*	**0.0**	*0.0*
Microgobius gulosus	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.1**	*0.1*	**0.0**	*0.0*	**0.0**	*0.0*
Micropogonias undulatus	**0.0**	*0.0*	**0.2**	*0.2*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*
Ophidion welshi	**0.0**	*0.0*	**0.5**	*0.3*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*
Poecilia latipinna	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.9**	*0.9*
Sciaenops ocellatus	**0.1**	*0.1*	**0.8**	*0.2*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.1**	*0.1*
Symphurus plagiusa	**0.2**	*0.1*	**2.1**	*0.7*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.1**	*0.1*
Syngnathus louisianae	**0.0**	*0.0*	**0.1**	*0.1*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*
Syngnathus scovelli	**0.0**	*0.0*	**1.2**	*0.5*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*
Total No. of Taxa	3		14		7		10		7		10	
Total No. of Individuals	5		170		79		72		45		148	
Species Richness	0.7		2.2		1.9		1.9		1.7		2.2	
Total Decapods	**2.8**	*1.0*	**103.3**	*24.7*	**7.9**	*3.3*	**88.9**	*28.0*	**6.1**	*1.7*	**48.8**	*10.3*
Alpheus heterochaelis	**0.0**	*0.0*	**0.6**	*0.5*	**0.0**	*0.0*	**0.1**	*0.1*	**0.0**	*0.0*	**4.3**	*1.2*
Callinectes sapidus	**1.2**	*0.3*	**34.5**	*4.5*	**1.9**	*0.8*	**17.4**	*5.5*	**3.3**	*1.5*	**8.3**	*1.4*
Palaemonetes pugio	**0.3**	*0.3*	**35.4**	*11.2*	**0.3**	*0.2*	**16.6**	*7.0*	**0.3**	*0.1*	**23.9**	*9.8*
Palaemonetes vulgaris	**0.0**	*0.0*	**0.1**	*0.1*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*
Penaeidae, unidentified	**0.1**	*0.1*	**17.8**	*9.2*	**0.0**	*0.0*	**0.0**	*0.0*	**0.1**	*0.1*	**1.9**	*1.0*
Penaeus aztecus	**0.1**	*0.1*	**6.8**	*3.3*	**0.7**	*0.6*	**15.1**	*6.5*	**0.1**	*0.1*	**2.5**	*0.8*
Penaeus duorarum	**0.1**	*0.1*	**0.1**	*0.1*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.1**	*0.1*
Penaeus setiferus	**1.1**	*1.0*	**8.0**	*4.0*	**5.0**	*2.8*	**39.7**	*14.6*	**2.3**	*1.0*	**7.9**	*2.2*
Total No. of Taxa	6		8		4		5		5		7	
Total No. of Individuals	33		1239		71		800		91		732	
Species Richness	1.5		3.1		1.9		2.9		2.0		2.9	
Mean Size												
Callinectes sapidus	**10.0**	*1.3*	**5.6**	*0.2*	**10.4**	*0.9*	**8.7**	*0.4*	**8.0**	*0.6*	**8.4**	*0.3*
Palaemonetes pugio	**12.0**	*0.0*	**13.9**	*0.3*	**21.5**	*1.5*	**16.4**	*0.7*	**13.3**	*1.2*	**13.1**	*0.2*
Penaeus aztecus	**14.0**	*0.0*	**19.7**	*1.2*	**21.3**	*5.5*	**20.1**	*0.8*	**37.5**	*3.5*	**19.3**	*1.6*
Penaeus setiferus	**32.8**	*2.1*	**21.5**	*0.7*	**16.3**	*1.1*	**19.5**	*0.7*	**26.4**	*1.7*	**21.0**	*0.8*

Table 5. Mean densities and (in italics) standard errors of fishes and decapods by site from throw trap samples in spring 1994. The number of taxa, individuals and species richness are shown after each major grouping. Decapod lengths or carapace widths are in mm.

	Spring 1994											
	Site 1 Sand (n = 9)		**Site 2** *Halodule* (n = 9)		**Site 3** Mud (n = 6)		**Site 4** *Ruppia* (n = 6)		**Site 5** Sand (n = 12)		**Site 6** *Ruppia* (n = 12)	
Total Fishes and Decapods	**3.8**	*1.5*	**137.9**	*32.5*	**18.3**	*10.7*	**28.7**	*11.7*	**9.9**	*2.3*	**28.0**	*13.2*
Total No. of Taxa	6		17		6		8		12		14	
Total No. of Individuals	34		1241		110		172		119		336	
Species Richness	1.5		3.1		2.0		2.2		2.1		2.5	
Total Fishes	**1.4**	*1.0*	**21.3**	*7.1*	**16.5**	*9.7*	**14.5**	*8.6*	**8.5**	*2.3*	**4.5**	*0.8*
Adinia xenica	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.1**	*0.1*
Archosargus probatocephalus	**0.0**	*0.0*	**0.7**	*0.6*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*
Brevoortia patronus	**0.8**	*0.8*	**0.0**	*0.0*	**8.3**	*7.9*	**1.0**	*0.8*	**0.0**	*0.0*	**0.0**	*0.0*
Citharichthys spilopterus	**0.0**	*0.0*	**0.1**	*0.1*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*
Clupeidae	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**3.3**	*2.4*	**0.0**	*0.0*
Cynoscion nebulosus	**0.0**	*0.0*	**0.2**	*0.2*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*
Cyprinodon variegatus	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**10.3**	*6.8*	**0.8**	*0.6*	**2.8**	*0.8*
Elops saurus	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.3**	*0.3*	**0.0**	*0.0*
Fish larvae, unidentified	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.2**	*0.2*	**0.0**	*0.0*
Fundulus grandis	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.2**	*0.2*	**0.1**	*0.1*	**0.1**	*0.1*
Fundulus similis	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.2**	*0.1*
Gobiidae	**0.0**	*0.0*	**0.2**	*0.2*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*
Gobionellus boleosoma	**0.0**	*0.0*	**8.0**	*1.8*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.1**	*0.1*
Gobiosoma robustum	**0.0**	*0.0*	**0.1**	*0.1*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*
Lagodon rhomboides	**0.0**	*0.0*	**3.0**	*0.8*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.6**	*0.2*
Leiostomus xanthurus	**0.6**	*0.2*	**0.1**	*0.1*	**0.0**	*0.0*	**0.5**	*0.3*	**0.3**	*0.2*	**0.1**	*0.1*
Lucania parva	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.1**	*0.1*
Menidia beryllina	**0.1**	*0.1*	**7.6**	*5.8*	**7.3**	*7.1*	**1.0**	*1.0*	**3.3**	*1.3*	**0.4**	*0.3*
Micropogonias undulatus	**0.0**	*0.0*	**0.4**	*0.2*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*
Mugil cephalus	**0.0**	*0.0*	**0.0**	*0.0*	**0.7**	*0.4*	**1.5**	*1.3*	**0.0**	*0.0*	**0.0**	*0.0*
Paralichthys lethostigma	**0.0**	*0.0*	**0.1**	*0.1*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*
Pogonias cromis	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.3**	*0.1*	**0.1**	*0.1*
Sciaenops ocellatus	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.1**	*0.1*	**0.0**	*0.0*
Symphurus plagiusa	**0.0**	*0.0*	**0.6**	*0.3*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*
Syngnathus scovelli	**0.0**	*0.0*	**0.2**	*0.2*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*
Synodus foetens	**0.0**	*0.0*	**0.0**	*0.0*	**0.2**	*0.2*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*
Total No. of Taxa	3		13		4		6		9		10	
Total No. of Individuals	13		192		99		87		102		54	
Species Richness	1.1		2.3		2.0		1.9		2.0		1.7	
Total Decapods	**2.3**	*0.9*	**116.6**	*27.3*	**1.8**	*1.2*	**14.2**	*7.0*	**1.4**	*0.4*	**23.5**	*12.7*
Callinectes sapidus	**0.6**	*0.2*	**6.7**	*1.7*	**0.8**	*0.3*	**0.8**	*0.5*	**0.6**	*0.3*	**0.6**	*0.3*
Palaemonetes pugio	**0.4**	*0.3*	**79.1**	*22.3*	**1.0**	*1.0*	**13.3**	*6.7*	**0.3**	*0.2*	**21.1**	*12.0*
Penaeus aztecus	**1.3**	*0.6*	**27.9**	*6.3*	**0.0**	*0.0*	**0.0**	*0.0*	**0.5**	*0.3*	**1.6**	*0.8*
Penaeus setiferus	**0.0**	*0.0*	**2.9**	*2.9*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.3**	*0.2*
Total No. of Species	3		4		2		2		3		4	
Total No. of Individuals	21		1049		11		85		17		282	
Species Richness	1.3		3.0		1.0		1.9		1.2		2.5	
Mean Sizes												
Callinectes sapidus	**7.6**	*1.2*	**11.1**	*0.9*	**24.4**	*5.0*	**15.8**	*4.1*	**30.2**	*5.7*	**18.7**	*3.3*
Palaemonetes pugio	**15.0**	*2.1*	**13.8**	*0.3*	**18.2**	*3.0*	**14.7**	*0.7*	**24.3**	*5.2*	**20.4**	*0.7*
Penaeus aztecus	**34.1**	*6.9*	**22.2**	*0.8*					**34.2**	*7.7*	**26.8**	*1.8*
Penaeus setiferus			**17.5**	*0.8*							**23.7**	*6.7*

Table 6. Mean densities and (in italics) standard errors of fishes and decapods by site from throw trap samples in summer 1994. The number of taxa, individuals and species richness are shown after each major grouping. Decapod lengths or carapace widths are in mm.

	Summer 1994											
	Site 1		Site 2		Site 3		Site 4		Site 5		Site 6	
	Sand	(n = 6)	*Halodule*	(n = 6)	Mud	(n = 9)	*Ruppia*	(n = 9)	Sand	(n = 9)	*Ruppia*	(n = 9)
Total Fishes and Decapods	**0.5**	*0.2*	**61.0**	*8.6*	**3.2**	*1.1*	**50.8**	*10.4*	**6.2**	*1.8*	**39.8**	*17.0*
Total No. of Taxa	3		17		6		14		12		14	
Total No. of Individuals	3		366		29		457		56		358	
Species Richness	0.5		2.6		1.5		2.7		1.7		2.6	
Total Fishes	**0.2**	*0.2*	**14.0**	*1.1*	**0.3**	*0.2*	**18.3**	*6.5*	**2.3**	*1.0*	**11.6**	*5.4*
Adinia xenica	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.2**	*0.2*	**0.0**	*0.0*	**0.7**	*0.6*
Archosargus probatocephalus	**0.0**	*0.0*	**0.2**	*0.2*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*
Cynoscion nebulosus	**0.0**	*0.0*	**0.2**	*0.2*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*
Cyprinodon variegatus	**0.0**	*0.0*	**0.0**	*0.0*	**0.1**	*0.1*	**13.8**	*6.7*	**0.7**	*0.6*	**6.7**	*4.5*
Cyprinodontidae	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.1**	*0.1*	**0.0**	*0.0*	**0.1**	*0.1*
Eucinostomus argenteus	**0.0**	*0.0*	**0.2**	*0.2*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.1**	*0.1*
Fundulus grandis	**0.0**	*0.0*	**0.2**	*0.2*	**0.0**	*0.0*	**0.2**	*0.2*	**0.0**	*0.0*	**0.3**	*0.2*
Fundulus pulvereus	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**2.3**	*1.4*	**0.0**	*0.0*	**1.8**	*1.1*
Fundulus similis	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.1**	*0.1*	**0.7**	*0.5*
Gobionellus boleosoma	**0.0**	*0.0*	**10.0**	*0.6*	**0.0**	*0.0*	**0.0**	*0.0*	**0.1**	*0.1*	**0.6**	*0.4*
Gobiosoma robustum	**0.0**	*0.0*	**0.3**	*0.2*	**0.1**	*0.1*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*
Lagodon rhomboides	**0.0**	*0.0*	**2.0**	*0.5*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*
Lucania parva	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.2**	*0.2*	**0.0**	*0.0*	**0.6**	*0.2*
Menidia beryllina	**0.0**	*0.0*	**0.0**	*0.0*	**0.1**	*0.1*	**1.1**	*0.4*	**1.0**	*0.9*	**0.0**	*0.0*
Mugil cephalus	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.2**	*0.2*	**0.1**	*0.1*	**0.0**	*0.0*
Mugil curema	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.1**	*0.1*	**0.0**	*0.0*
Opsanus beta	**0.0**	*0.0*	**0.2**	*0.2*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*
Orthopristis chrysoptera	**0.0**	*0.0*	**0.2**	*0.2*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*
Poecilia latipinna	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.1**	*0.1*	**0.0**	*0.0*	**0.1**	*0.1*
Pogonias cromis	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.2**	*0.2*	**0.0**	*0.0*
Symphurus plagiusa	**0.0**	*0.0*	**0.3**	*0.2*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*
Syngnathus scovelli	**0.0**	*0.0*	**0.3**	*0.3*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*
Synodus foetens	**0.2**	*0.2*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*
Total No. of Species	1		11		3		9		7		10	
Total No. of Individuals	1		84		3		165		21		104	
Species Richness	0.0		1.9		0.5		2.2		1.3		2.0	
Total Decapods	**0.3**	*0.2*	**47.0**	*7.8*	**2.9**	*1.1*	**32.4**	*6.2*	**3.9**	*1.7*	**28.2**	*16.4*
Alpheus heterochaelis	**0.0**	*0.0*	**0.3**	*0.3*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*
Callinectes sapidus	**0.2**	*0.2*	**8.3**	*3.0*	**1.4**	*0.7*	**11.1**	*2.3*	**1.3**	*0.4*	**4.7**	*2.2*
Palaemonetes pugio	**0.0**	*0.0*	**20.7**	*9.7*	**0.2**	*0.2*	**16.6**	*3.7*	**0.1**	*0.1*	**18.7**	*13.2*
Penaeidae, unidentified	**0.0**	*0.0*	**7.0**	*2.9*	**0.0**	*0.0*	**0.3**	*0.2*	**1.1**	*0.6*	**0.8**	*0.5*
Penaeus aztecus	**0.2**	*0.2*	**9.2**	*1.4*	**0.0**	*0.0*	**1.2**	*0.5*	**0.0**	*0.0*	**0.0**	*0.0*
Penaeus setiferus	**0.0**	*0.0*	**1.5**	*0.9*	**1.2**	*0.6*	**3.2**	*1.7*	**1.3**	*0.7*	**4.1**	*1.6*
Total No. of Taxa	2		6		3		5		5		4	
Total No. of Individuals	2		282		26		292		35		254	
Species Richness	0.3		2.5		1.4		2.5		1.5		2.4	
Mean Size												
Callinectes sapidus	**30.0**	*0.0*	**7.5**	*1.2*	**16.3**	*1.5*	**15.5**	*0.6*	**16.9**	*2.3*	**12.5**	*1.0*
Palaemonetes pugio			**15.8**	*0.5*	**22.5**	*3.5*	**20.4**	*0.4*	**10.0**	*0.0*	**20.4**	*0.7*
Penaeus aztecus	**39.0**	*0.0*	**31.5**	*1.9*			**33.1**	*3.6*				
Penaeus setiferus			**18.1**	*1.9*	**38.6**	*3.2*	**37.1**	*3.0*	**28.0**	*3.2*	**38.2**	*2.4*

Table 7. Mean densities and (in italics) standard errors of fishes and decapods by site from throw trap samples in fall 1994. The number of taxa, individuals and species richness are shown after each major grouping. Decapod lengths or carapace widths are in mm.

	Fall 1994											
	Site 1		Site 2		Site 3		Site 4		Site 5		Site 6	
	Sand (n = 6)		*Halodule* (n = 6)		Mud (n = 6)		*Ruppia* (n = 6)		Sand (n = 3)		*Ruppia* (n = 3)	
Total Fishes and Decapods	**2.3**	*1.1*	**122.7**	*10.8*	**2.8**	*1.0*	**36.2**	*13.6*	**65.7**	*17.4*	**72.0**	*14.7*
Total No. of Taxa	6		15		5		10		12		11	
Total No. of Individuals	14		736		17		217		197		216	
Species Richness	1.1		2.9		1.2		2.3		2.3		2.3	
Total Fishes	**0.5**	*0.5*	**13.3**	*1.4*	**1.5**	*0.5*	**14.0**	*5.0*	**9.7**	*2.4*	**9.3**	*3.8*
Adinia xenica	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.7**	*0.7*	**0.0**	*0.0*
Anchoa mitchilli	**0.5**	*0.5*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*
Cyprinodon variegatus	**0.0**	*0.0*	**0.0**	*0.0*	**1.0**	*0.5*	**6.8**	*2.1*	**3.7**	*3.7*	**5.7**	*5.7*
Fundulus pulvereus	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.3**	*0.2*	**0.0**	*0.0*	**0.0**	*0.0*
Gobiidae	**0.0**	*0.0*	**0.3**	*0.3*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*
Gobionellus boleosoma	**0.0**	*0.0*	**6.7**	*1.7*	**0.0**	*0.0*	**0.0**	*0.0*	**3.0**	*1.7*	**2.3**	*1.5*
Gobiosoma bosc	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.2**	*0.2*	**0.0**	*0.0*	**0.0**	*0.0*
Gobiosoma robustum	**0.0**	*0.0*	**2.2**	*0.6*	**0.0**	*0.0*	**0.0**	*0.0*	**1.3**	*1.3*	**0.3**	*0.3*
Lagodon rhomboides	**0.0**	*0.0*	**0.2**	*0.2*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*
Lucania parva	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.2**	*0.2*	**0.0**	*0.0*	**0.0**	*0.0*
Menidia beryllina	**0.0**	*0.0*	**0.0**	*0.0*	**0.3**	*0.3*	**0.7**	*0.5*	**0.7**	*0.7*	**0.3**	*0.3*
Microgobius gulosus	**0.0**	*0.0*	**0.0**	*0.0*	**0.2**	*0.2*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*
Ophidion welshi	**0.0**	*0.0*	**0.3**	*0.3*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*
Opsanus beta	**0.0**	*0.0*	**0.2**	*0.2*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*
Poecilia latipinna	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**5.8**	*2.7*	**0.0**	*0.0*	**0.0**	*0.0*
Sciaenops ocellatus	**0.0**	*0.0*	**0.2**	*0.2*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*
Symphurus plagiusa	**0.0**	*0.0*	**2.0**	*0.3*	**0.0**	*0.0*	**0.0**	*0.0*	**0.3**	*0.3*	**0.7**	*0.7*
Syngnathus scovelli	**0.0**	*0.0*	**1.3**	*0.6*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*	**0.0**	*0.0*
Total No. of Taxa	1		9		3		6		6		5	
Total No. of Individuals	3		80		9		84		29		28	
Species Richness	0.5		1.9		1.0		1.9		1.5		1.4	
Total Decapods	**1.8**	*1.1*	**109.3**	*11.3*	**1.3**	*0.8*	**22.2**	*8.8*	**56.0**	*19.0*	**62.7**	*18.5*
Alpheus heterochaelis	**0.2**	*0.2*	**0.3**	*0.2*	**0.0**	*0.0*	**0.0**	*0.0*	**0.3**	*0.3*	**1.7**	*1.2*
Callinectes sapidus	**1.2**	*0.8*	**19.8**	*4.9*	**0.5**	*0.3*	**3.0**	*1.5*	**4.7**	*1.8*	**3.3**	*1.9*
Palaemonetes pugio	**0.2**	*0.2*	**60.8**	*11.6*	**0.0**	*0.0*	**9.8**	*4.5*	**12.0**	*11.5*	**21.7**	*16.2*
Penaeidae, unidentified	**0.0**	*0.0*	**11.3**	*4.7*	**0.0**	*0.0*	**0.0**	*0.0*	**15.3**	*9.0*	**14.7**	*3.2*
Penaeus aztecus	**0.2**	*0.2*	**4.2**	*1.1*	**0.0**	*0.0*	**0.2**	*0.2*	**1.0**	*0.6*	**0.7**	*0.7*
Penaeus setiferus	**0.2**	*0.2*	**12.8**	*4.9*	**0.8**	*0.8*	**9.2**	*7.2*	**22.7**	*7.7*	**20.7**	*9.0*
Total No. of Taxa	5		6		2		4		6		6	
Total No. of Individuals	11		656		8		133		168		188	
Species Richness	1.0		2.8		0.9		2.1		2.2		2.3	
Mean Size												
Callinectes sapidus	**11.1**	*3.9*	**7.7**	*0.4*	**8.0**	*1.0*	**21.2**	*2.6*	**15.6**	*1.8*	**10.0**	*1.2*
Palaemonetes pugio			**14.9**	*0.2*			**18.3**	*0.8*	**27.3**	*0.7*	**25.6**	*0.6*
Penaeus aztecus	**42.0**	*0.0*	**26.3**	*3.3*			**53.0**	*0.0*	**40.0**	*4.9*	**62.0**	*0.0*
Penaeus setiferus	**30.0**	*0.0*	**22.3**	*1.0*	**33.3**	*1.2*	**35.2**	*1.3*	**32.8**	*1.3*	**40.1**	*2.0*

Table 8. Results of ANOVA on fish and decapod log-transformed densities using main effect (site) partitioned through contrasts.

	Fall 1993			Spring 1994			Summer 1994			Fall 1994		
Source of Variance	**df**	**ss**	**p**	**df**	**ss**	**p**	**df**	**ss**	**p**	**df**	**ss**	**p**
Total Fish and Decapods												
Sites	5	1.12	**0.0001**	5	56.21	**0.0001**	5	83.38	**0.0001**	5	73.77	**0.0001**
Veg vs. Non	1	99.95	**0.0001**	1	30.89	**0.0001**	1	78.83	**0.0001**	1	25.79	**0.0001**
Halodule vs. *Ruppia*	1	2.33	0.1425	1	18.53	**0.0004**	1	1.84	0.1255	1	4.89	**0.0185**
Sand vs. Mud	1	2.00	0.1739	1	0.31	0.6242	1	0.19	0.6184	1	6.61	**0.0072**
Error	66	69.87		48	60.29		42	31.62		24	18.38	
Fishes												
Sites	5	34.37	**0.0001**	5	23.08	**0.0030**	5	50.81	**0.0001**	5	25.73	**0.0001**
Veg vs. Non	1	27.55	**0.0001**	1	6.73	**0.0168**	1	46.10	**0.0001**	1	9.86	**0.0005**
Halodule vs. *Ruppia*	1	0.40	0.5317	1	4.99	0.0381	1	0.81	0.2309	1	0.77	0.2723
Sand vs. Mud	1	1.32	0.2559	1	0.97	0.3514	1	0.58	0.3105	1	0.72	0.2878
Error	66	66.37		48	52.61		42	23.13		24	14.70	
Decapods												
Sites	5	115.71	**0.0001**	5	86.22	**0.0001**	5	68.83	**0.0001**	5	81.08	**0.0001**
Veg vs. Non	1	104.96	**0.0001**	1	48.81	**0.0001**	1	65.77	**0.0001**	1	27.21	**0.0001**
Halodule vs. *Ruppia*	1	3.75	0.0600	1	31.76	**0.0001**	1	4.18	0.0527	1	6.64	**0.0056**
Sand vs. Mud	1	0.76	0.3917	1	0.09	0.7841	1	0.88	0.3690	1	10.11	**0.0001**
Error	66	67.61		48	59.66		42	44.19		24	17.20	
Commercial Shrimp												
Sites	5	50.24	**0.0002**	5	63.99	**0.0001**	5	28.26	**0.0001**	5	60.77	**0.0001**
Veg vs. Non	1	46.03	**0.0001**	1	12.03	**0.0001**	1	19.88	**0.0001**	1	11.69	**0.0007**
Halodule vs. *Ruppia*	1	0.16	0.7671	1	48.37	**0.0001**	1	11.53	**0.0006**	1	2.90	0.0662
Sand vs. Mud	1	0.80	0.5044	1	0.99	0.1272	1	0.11	0.7169	1	8.53	**0.0030**
Error	66	1.17		48	19.69		42	35.60		24	18.80	
Grass Shrimp												
Sites	5	96.25	**0.0001**	5	79.12	**0.0001**	5	59.16	**0.0001**	5	67.09	**0.0001**
Veg vs. Non	1	86.14	**0.0001**	1	55.50	**0.0001**	1	54.18	**0.0001**	1	35.57	**0.0001**
Halodule vs. *Ruppia*	1	5.71	0.0320	1	17.69	**0.0018**	1	1.59	0.2045	1	11.37	**0.0011**
Sand vs. Mud	1	0.02	0.9078	1	0.05	0.8592	1	0.07	0.7825	1	2.04	0.1294
Error	66	78.54		48	77.71		42	40.22		24	19.80	
Blue Crab												
Sites	5	75.00	**0.0001**	5	17.12	**0.0001**	5	24.29	**0.0001**	5	23.60	**0.0001**
Veg vs. Non	1	60.68	**0.0001**	1	3.03	**0.0009**	1	19.79	**0.0001**	1	5.17	**0.0066**
Halodule vs. *Ruppia*	1	11.76	**0.0001**	1	12.63	**0.0001**	1	0.02	0.8634	1	9.27	**0.0006**
Sand vs. Mud	1	0.00	0.9451	1	0.16	0.4172	1	0.35	0.4666	1	2.11	0.0700
Error	66	40.33		48	11.63		42	27.40		24	14.06	

Table 9. Mean values and (in italics) standard errors of environmental and floral data by site and season collected in throw traps during fall 1993, and spring, summer and fall 1994.

	Fall 1993											
Independent variables	**Site 1**		**Site 2**		**Site 3**		**Site 4**		**Site 5**		**Site 6**	
	Sand		*Halodule*		Mud		*Ruppia*		Sand		*Ruppia*	
Water Temperature (°C)	**20.5**	*1.63*	**20.5**	*1.63*	**24.9**	*1.94*	**24.9**	*1.94*	**24.6**	*1.55*	**24.5**	*1.56*
Salinity (ppt)	**27.3**	*0.58*	**27.3**	*0.58*	**23.0**	*1.18*	**23.0**	*1.18*	**29.6**	*1.10*	**29.6**	*1.12*
Dissolved Oxygen (ppm)	**7.3**	*0.31*	**7.5**	*0.32*	**6.2**	*0.74*	**6.2**	*0.73*	**5.4**	*0.72*	**5.7**	*0.81*
Turbidity (FTU)	**12.7**	*1.75*	**10.0**	*1.49*	**34.9**	*10.13*	**35.1**	*6.77*	**11.7**	*1.79*	**12.6**	*1.72*
Depth (cm)	**32.4**	*3.50*	**30.7**	*3.97*	**34.4**	*4.00*	**36.3**	*3.41*	**23.0**	*2.35*	**22.1**	*2.46*
Vegetation Cover (%)	**0.0**	*0.00*	**99.6**	*0.42*	**0.0**	*0.00*	**43.3**	*7.55*	**0.3**	*0.33*	**28.7**	*6.06*

	Spring 1994											
Independent variables	**Site 1**		**Site 2**		**Site 3**		**Site 4**		**Site 5**		**Site 6**	
	Sand		*Halodule*		Mud		*Ruppia*		Sand		*Ruppia*	
Water Temperatun (°C)	**23.9**	*0.56*	**23.9**	*0.56*	**28.5**	*2.01*	**28.5**	*2.01*	**24.7**	*0.99*	**24.7**	*0.99*
Salinity (ppt)	**22.3**	*0.93*	**22.3**	*0.93*	**6.5**	*0.67*	**6.5**	*0.67*	**20.2**	*0.98*	**20.2**	*0.98*
Dissolved Oxygen (ppm)	**8.6**	*0.53*	**9.0**	*0.59*	**9.1**	*0.30*	**9.0**	*0.51*	**6.9**	*0.66*	**7.7**	*0.88*
Turbidity (FTU)	**12.3**	*2.01*	**10.8**	*1.38*	**45.9**	*9.91*	**43.1**	*5.88*	**20.3**	*3.97*	**27.0**	*4.48*
Depth (cm)	**35.9**	*2.11*	**34.9**	*2.55*	**28.4**	*1.67*	**29.6**	*1.04*	**29.3**	*4.15*	**29.5**	*4.10*
Vegetation Cover (%)	**0.0**	*0.00*	**68.9**	*11.48*	**0.0**	*0.00*	**50.8**	*8.60*	**0.3**	*0.33*	**49.6**	*5.66*

	Summer 1994											
Independent variables	**Site 1**		**Site 2**		**Site 3**		**Site 4**		**Site 5**		**Site 6**	
	Sand		*Halodule*		Mud		*Ruppia*		Sand		*Ruppia*	
Water Temperature (°C)	**31.3**	*1.23*	**31.3**	*1.23*	**29.6**	*0.39*	**29.6**	*0.39*	**32.8**	*0.47*	**32.8**	*0.47*
Salinity (ppt)	**23.8**	*1.45*	**23.8**	*1.45*	**7.7**	*0.73*	**7.7**	*0.73*	**25.0**	*1.19*	**25.0**	*1.19*
Dissolved Oxygen (ppm)	**5.4**	*0.23*	**5.7**	*0.30*	**8.3**	*0.79*	**8.5**	*0.91*	**8.7**	*0.73*	**9.2**	*0.47*
Turbidity (FTU)	**8.2**	*1.68*	**7.8**	*1.23*	**23.0**	*4.99*	**12.4**	*2.46*	**29.5**	*7.50*	**26.6**	*3.39*
Depth (cm)	**45.8**	*0.82*	**46.6**	*2.06*	**29.4**	*1.23*	**33.9**	*1.26*	**18.3**	*3.23*	**18.4**	*2.84*
Vegetation Cover (%)	**0.0**	*0.00*	**100.0**	*0.00*	**1.1**	*1.11*	**81.1**	*3.89*	**0.0**	*0.00*	**40.0**	*6.87*

	Fall 1994											
Independent variables	**Site 1**		**Site 2**		**Site 3**		**Site 4**		**Site 5**		**Site 6**	
	Sand		*Halodule*		Mud		*Ruppia*		Sand		*Ruppia*	
Water Temperature (°C)	**23.8**	*0.78*	**23.8**	*0.78*	**23.0**	*0.45*	**23.0**	*0.45*	**26.0**	*0.00*	**26.0**	*0.00*
Salinity (ppt)	**22.0**	*0.89*	**22.0**	*0.89*	**6.5**	*1.57*	**6.5**	*1.57*	**25.0**	*0.00*	**25.0**	*0.00*
Dissolved Oxygen (ppm)	**7.5**	*0.69*	**7.3**	*0.34*	**8.9**	*0.94*	**10.2**	*0.76*	**6.5**	*1.25*	**6.9**	*0.98*
Turbidity (FTU)	**8.7**	*1.58*	**15.0**	*2.46*	**17.8**	*9.16*	**45.1**	*8.67*	**47.9**	*15.67*	**46.7**	*27.24*
Depth (cm)	**33.6**	*4.96*	**34.8**	*6.43*	**14.4**	*2.72*	**18.4**	*1.25*	**16.5**	*1.26*	**16.7**	*2.35*
Vegetation Cover (%)	**0.0**	*0.00*	**100.0**	*0.00*	**0.0**	*0.00*	**83.3**	*6.15*	**0.0**	*0.00*	**11.0**	*2.08*

Table 10. Results of forward stepwise multiple regression analyses on fish and decapod log-transformed densities by season using independent variables water temperature (WTEMP), salinity (SAL) , dissolved oxygen (DO), turbidity (TURB), mean depth (MDEPTH), and vegetation cover (COVER).

Dependent Variable	Step 1	Adjusted R^2	Step 2	Adjusted R^2	Final Step	Adjusted R^2
FALL 1993						
Total Fishes and Decapods			COVER, WTEMP	0.491		
Fishes			COVER, WTEMP	0.257		
Decapods			COVER, TURB	0.546		
Commercial Shrimp			WTEMP, COVER	0.544		
Grass Shrimp	COVER	0.495				
Blue Crab	COVER	0.638				
Spring 1994						
Total Fishes and Decapods	COVER	0.498				
Fishes			COVER, MDEPTH	0.240		
Decapods	COVER	0.614				
Commercial Shrimp			COVER, SAL	0.457		
Grass Shrimp			COVER, WTEMP	0.745		
Blue Crab	COVER	0.108				
Summer 1994						
Total Fishes and Decapods	COVER	0.671				
Fishes			COVER, MDEPTH	0.641		
Decapods	COVER	0.630				
Commercial Shrimp			COVER, DO	0.390		
Grass Shrimp	COVER	0.709				
Blue Crab	COVER	0.441				
FALL 1994						
Total Fishes and Decapods			COVER, WTEMP	0.541		
Fishes					COVER, WTEMP, MDEPTH	0.552
Decapods					COVER, MDEPTH, WTEMP, SAL, DO	0.743
Commercial Shrimp					COVER, WTEMP, MDEPTH, DO, SAL	0.688
Grass Shrimp					COVER, SAL, TURB	0.733
Blue Crab					COVER, SAL, MDEPTH	0.536

APPENDIX B: FIGURES

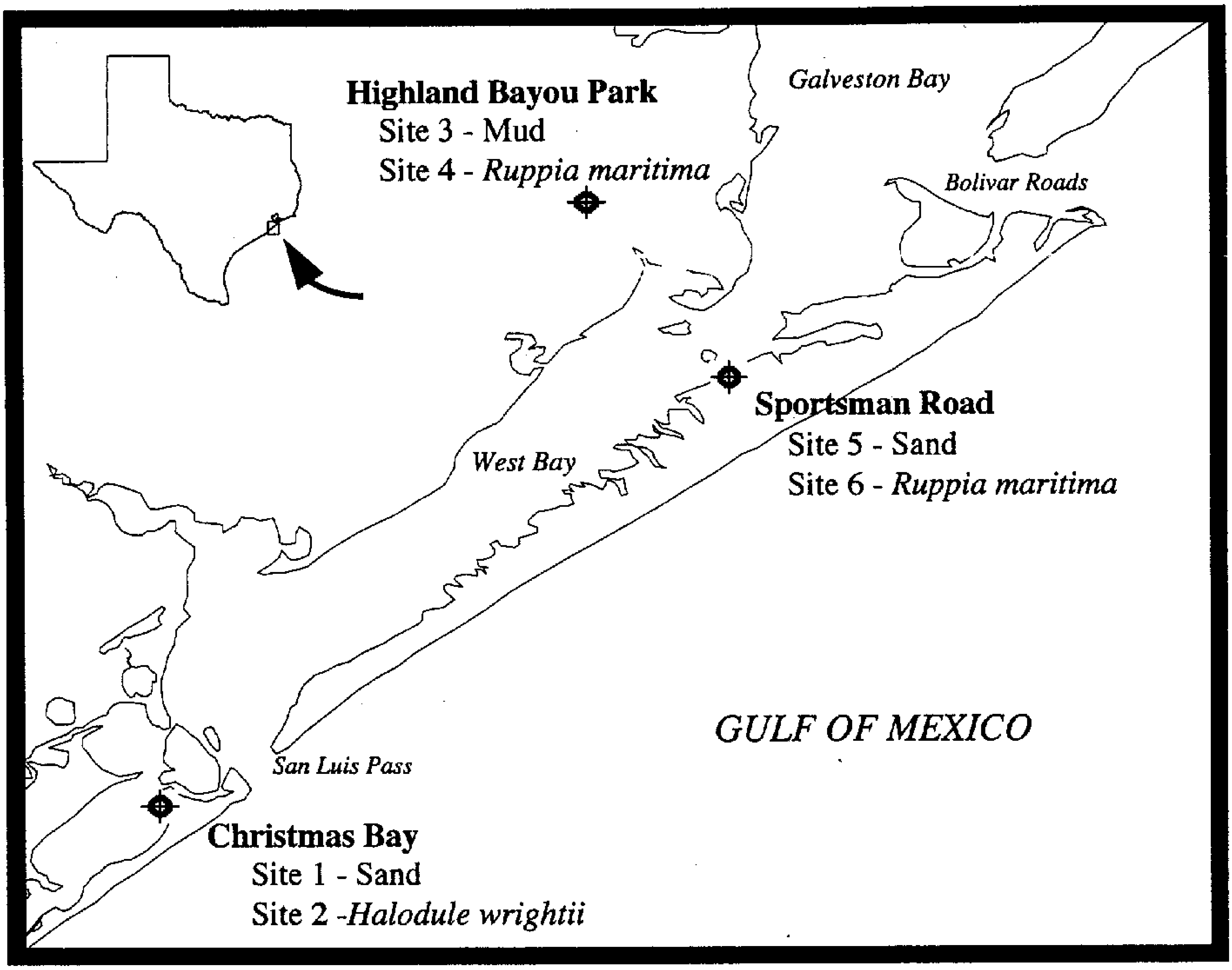


Figure 1. Location of study sites in the Galveston Bay Ecosytem, Texas.

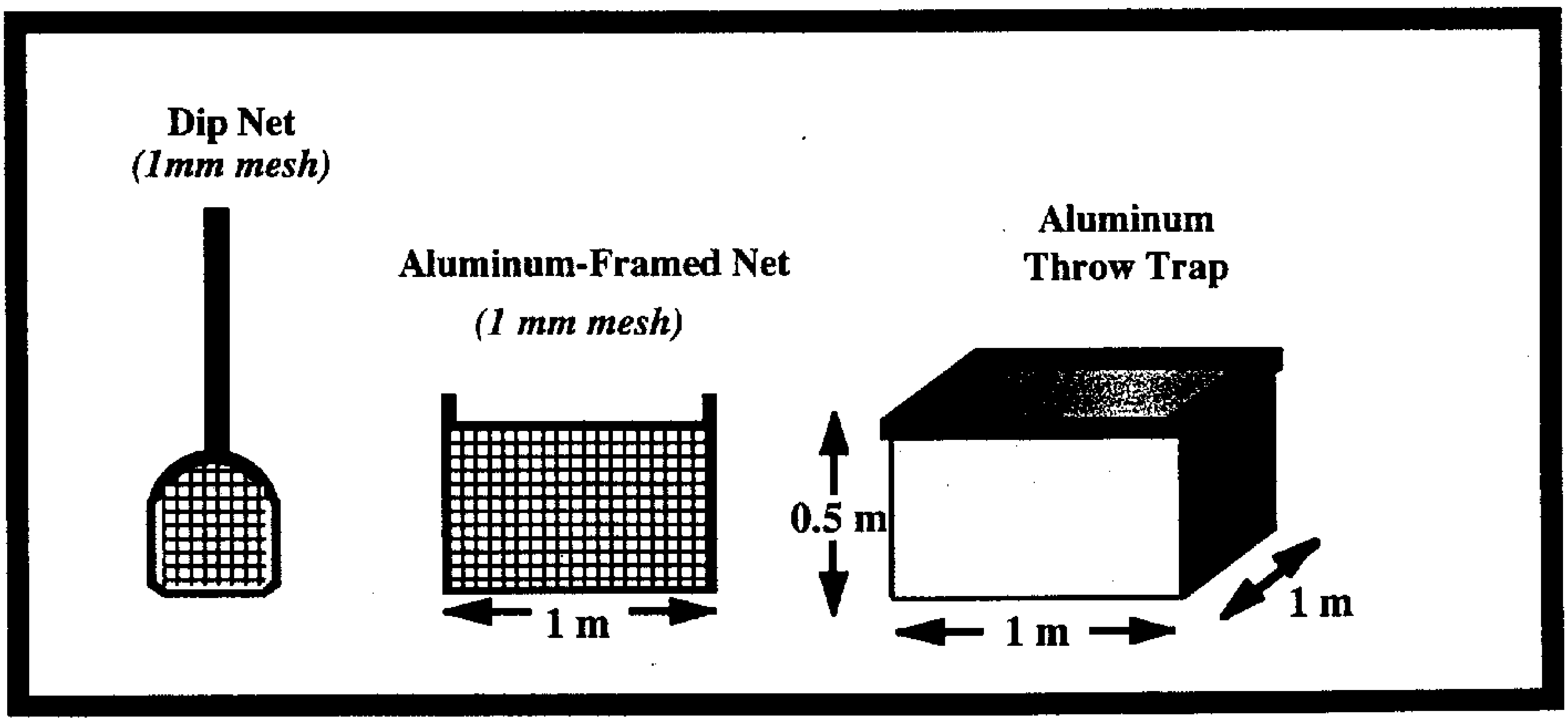


Figure 2. Throw trap and dip nets used to sample SAV and non-vegetated habitats.

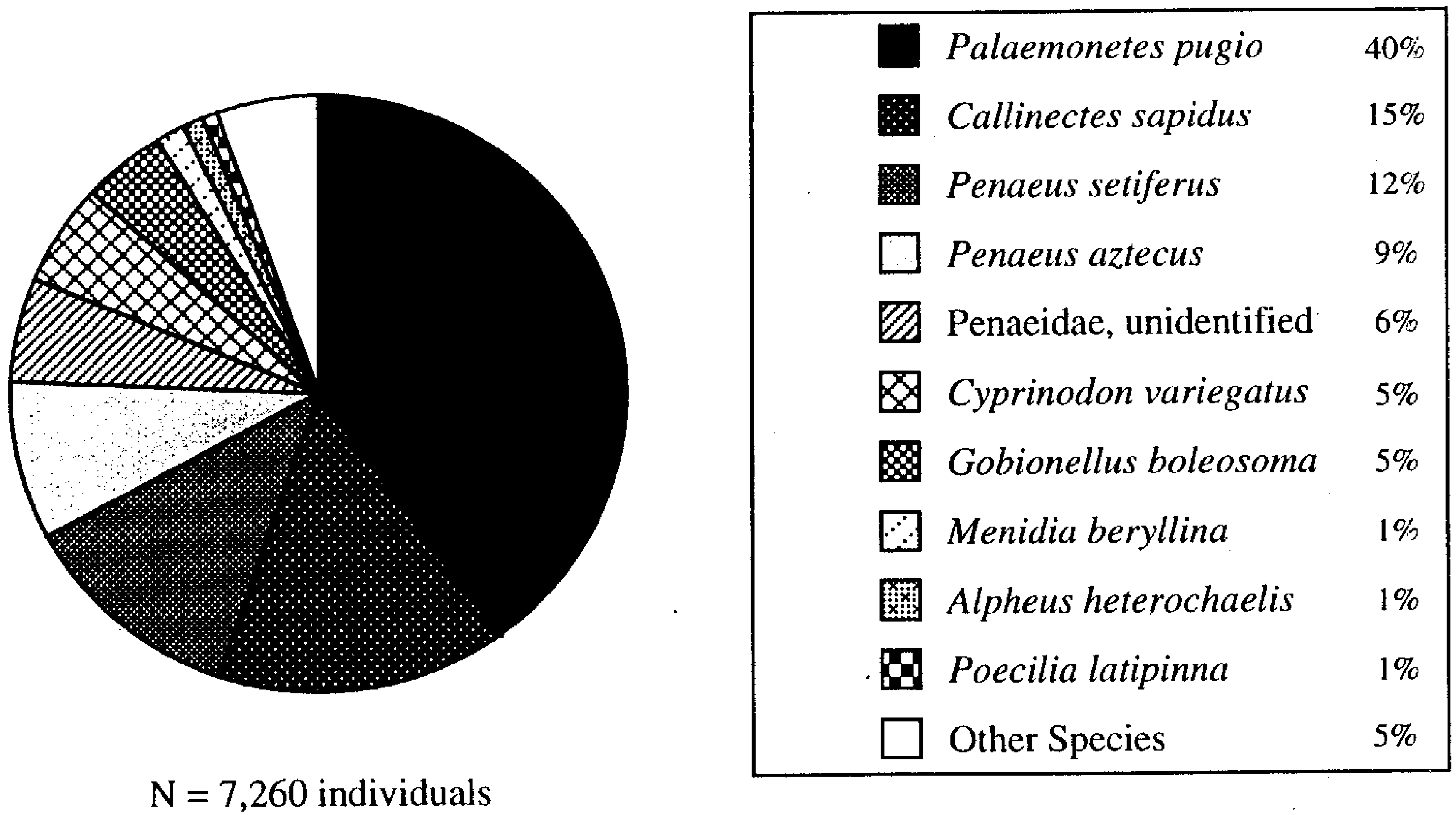


Figure 3. Ten most abundant taxa collected in vegetated habitats (*Halodule* and *Ruppia*) from 102 m^2 throw trap samples taken during the period 30 September 1993 to 28 November 1994.

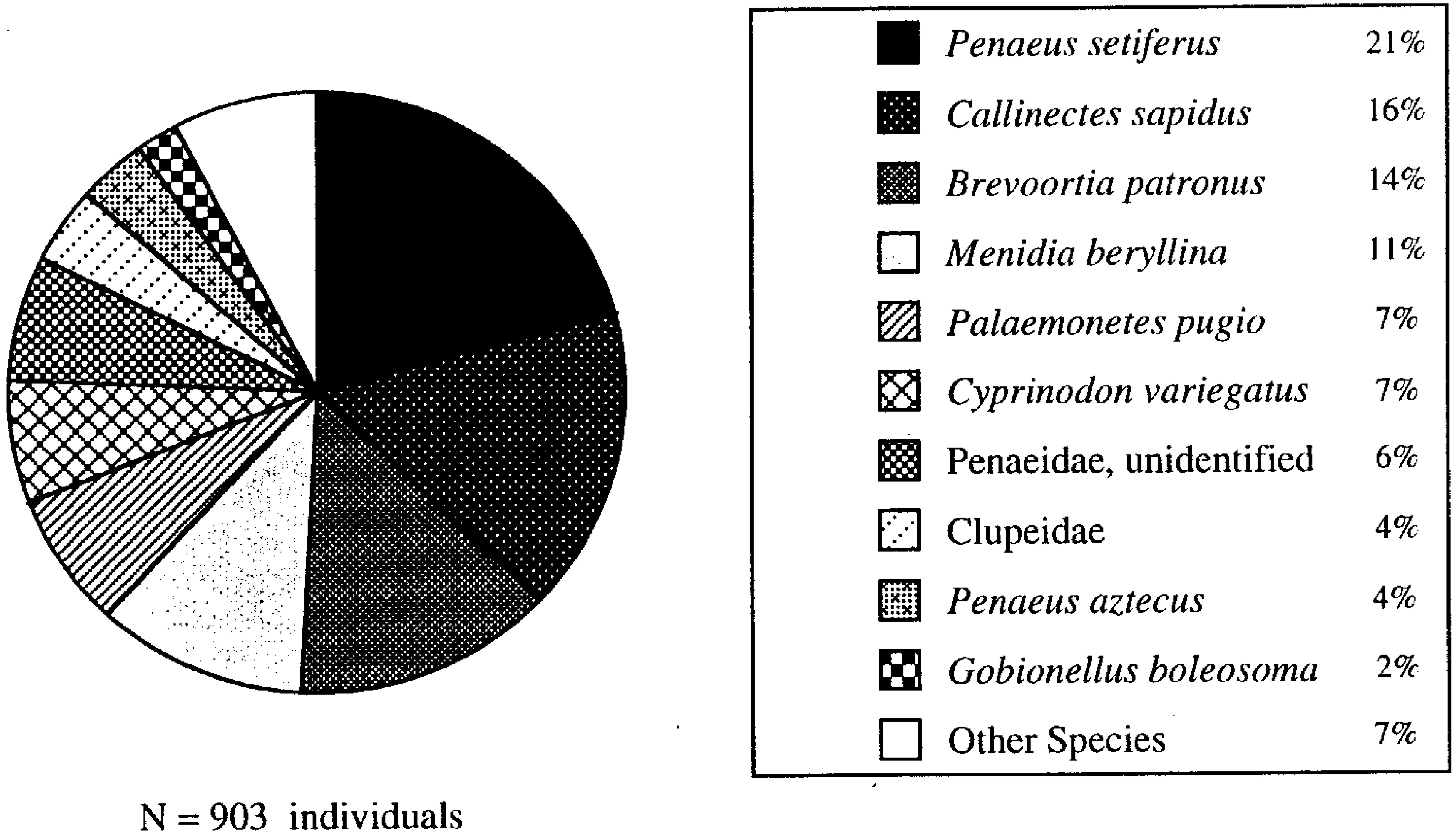


Figure 4. Ten most abundant taxa collected in non-vegetated habitats (sand and mud) from 102 m^2 throw trap samples taken during the period 30 September 1993 to 28 November 1994.

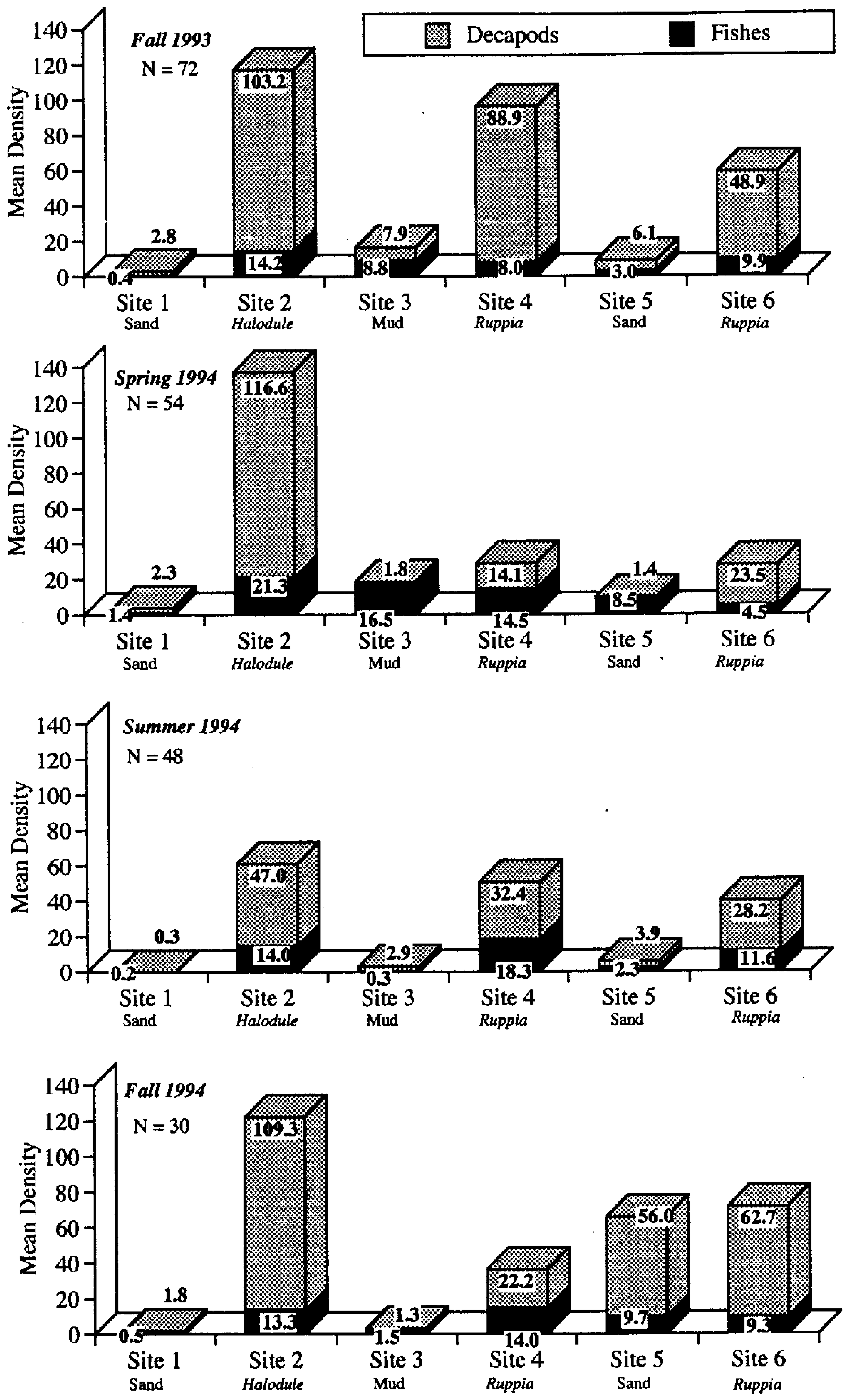


Figure 5. Distribution of fish and decapod mean densities (number per m^2) by site and season collected from 204 throw trap samples taken during the period 30 September 1993 to 28 November 1994.

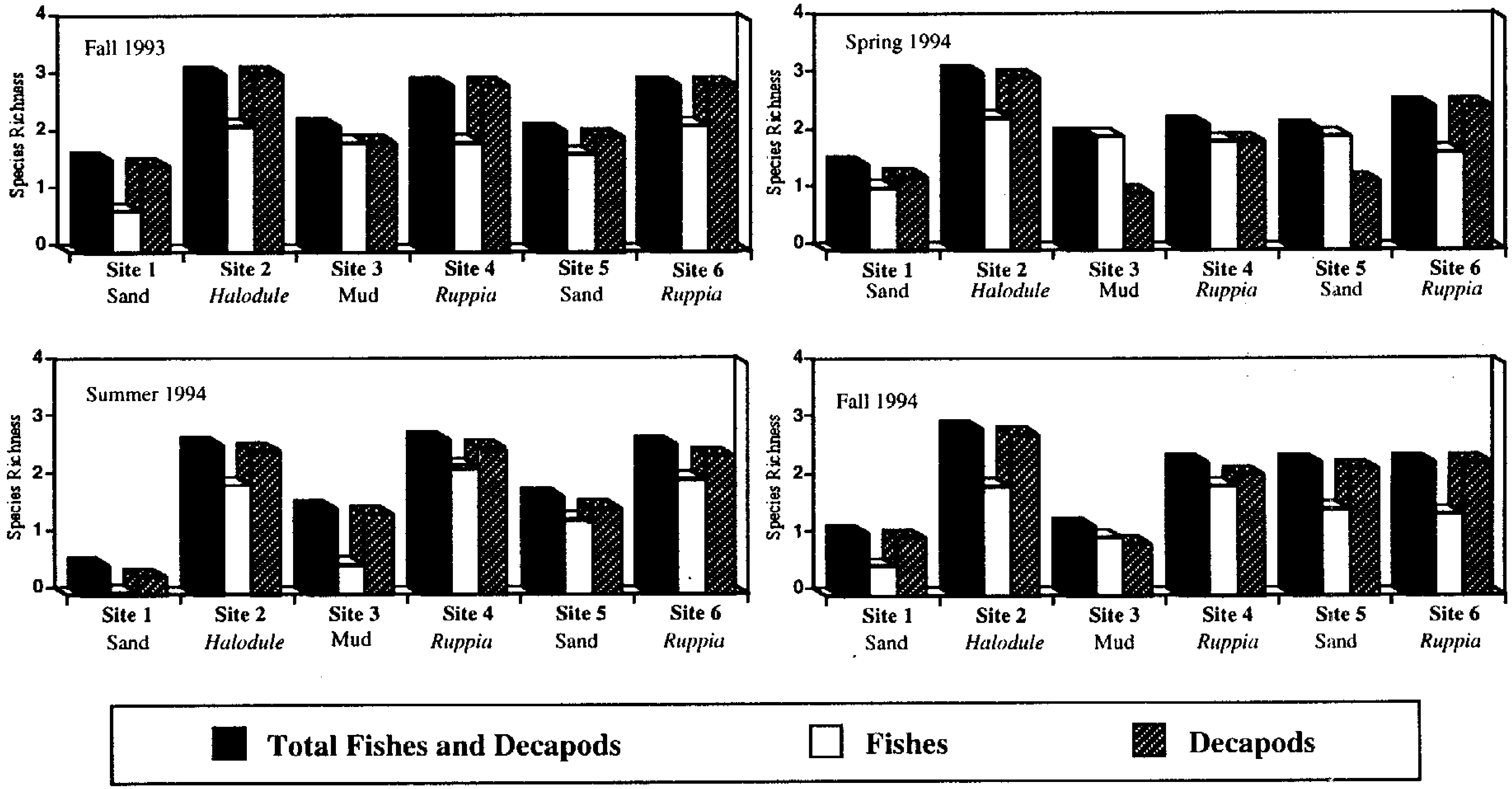


Figure 6. Species richness by site and season for total fishes and decapods, fishes and decapods collected in throw traps samples. Species richness was calculated as described by Pielou, 1969.

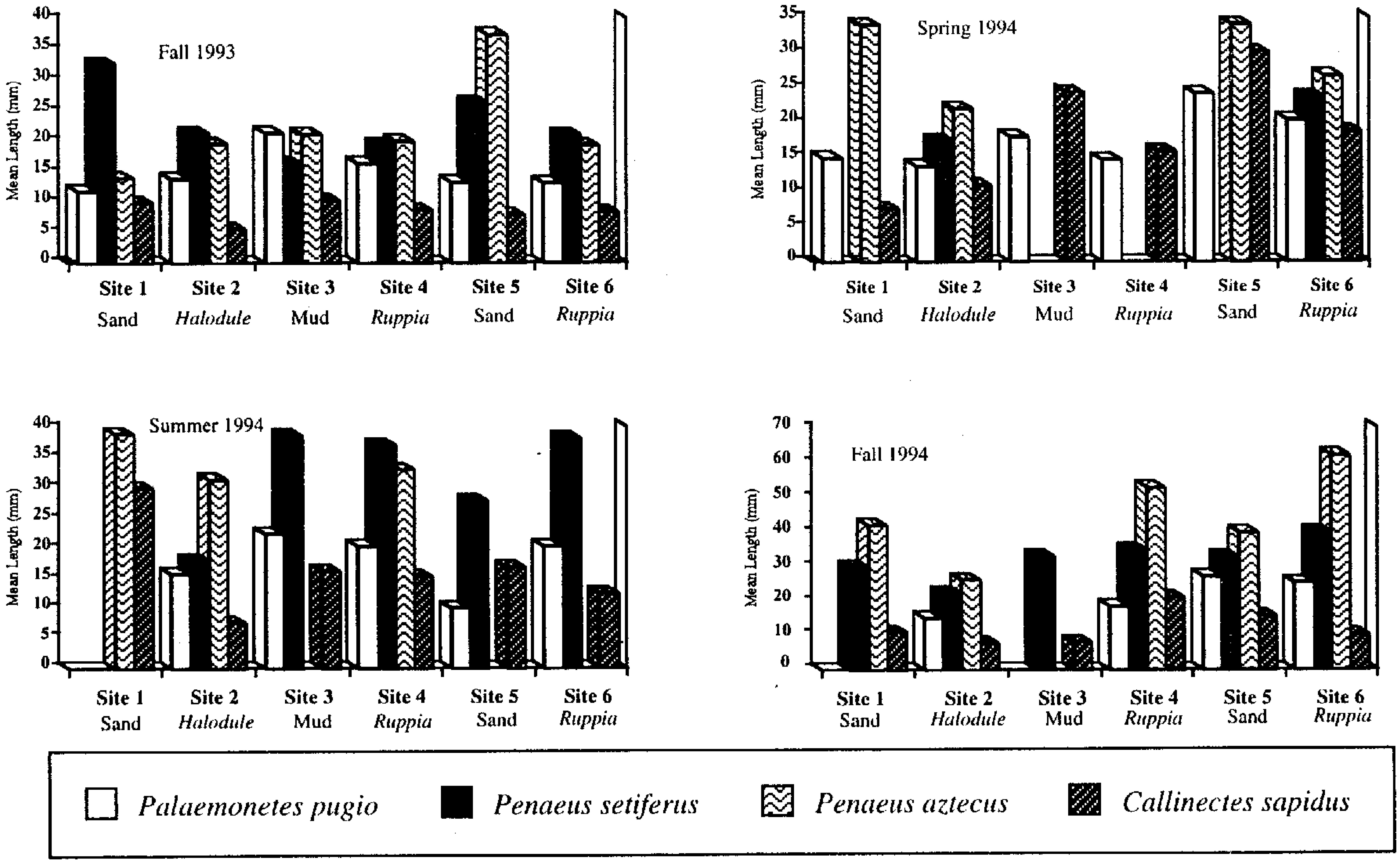


Figure 7. Mean lengths (mm) of dominant decapods by site and season. *Palaemonetes pugio* and *Penaeus* spp. measurements are total length, with *Callinectes sapidus* lengths recorded as carapace width.

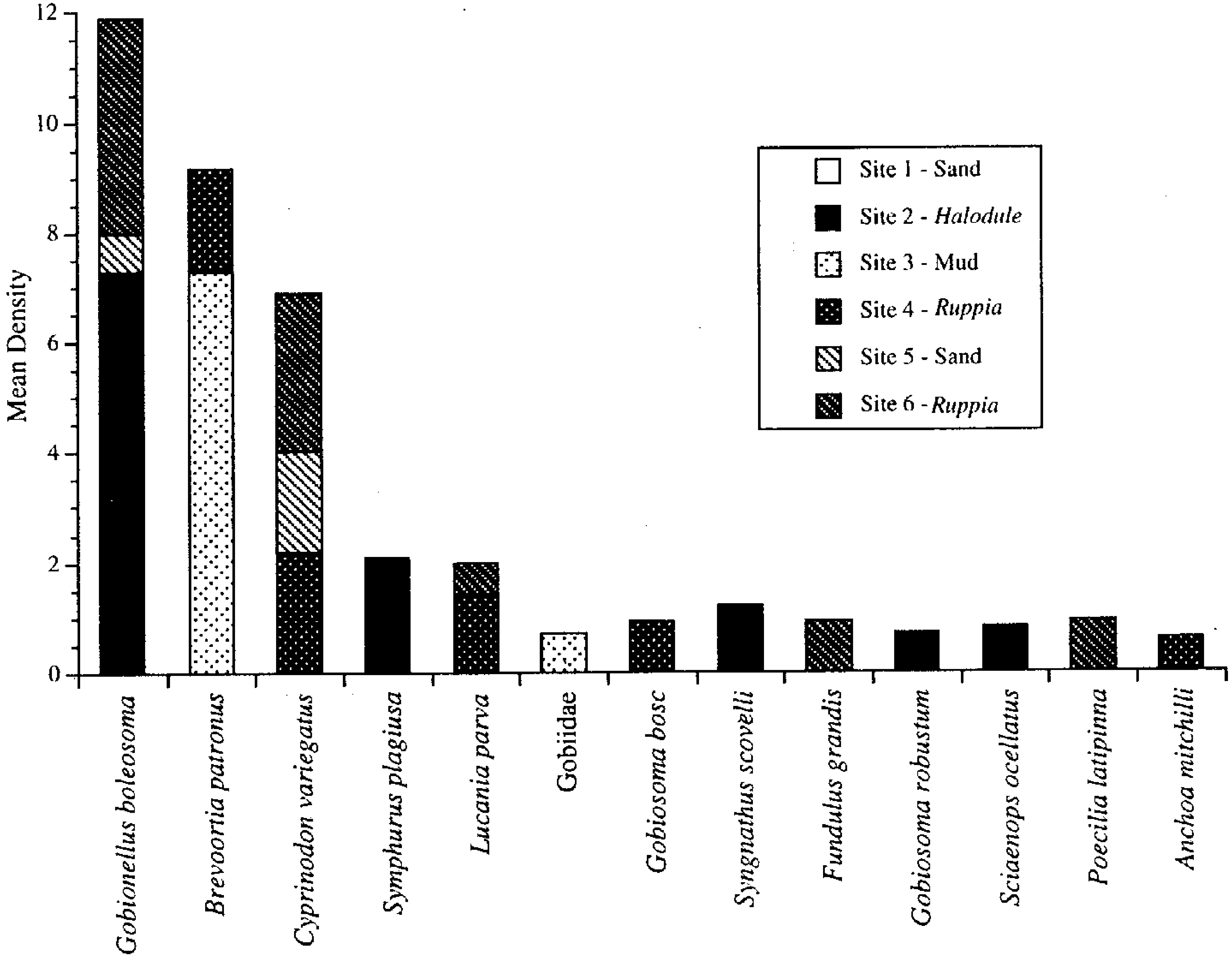


Figure 8. Fish taxa with mean densities exceeding 0.5 individuals per m^2 collected in throw trap samples in fall 1993.

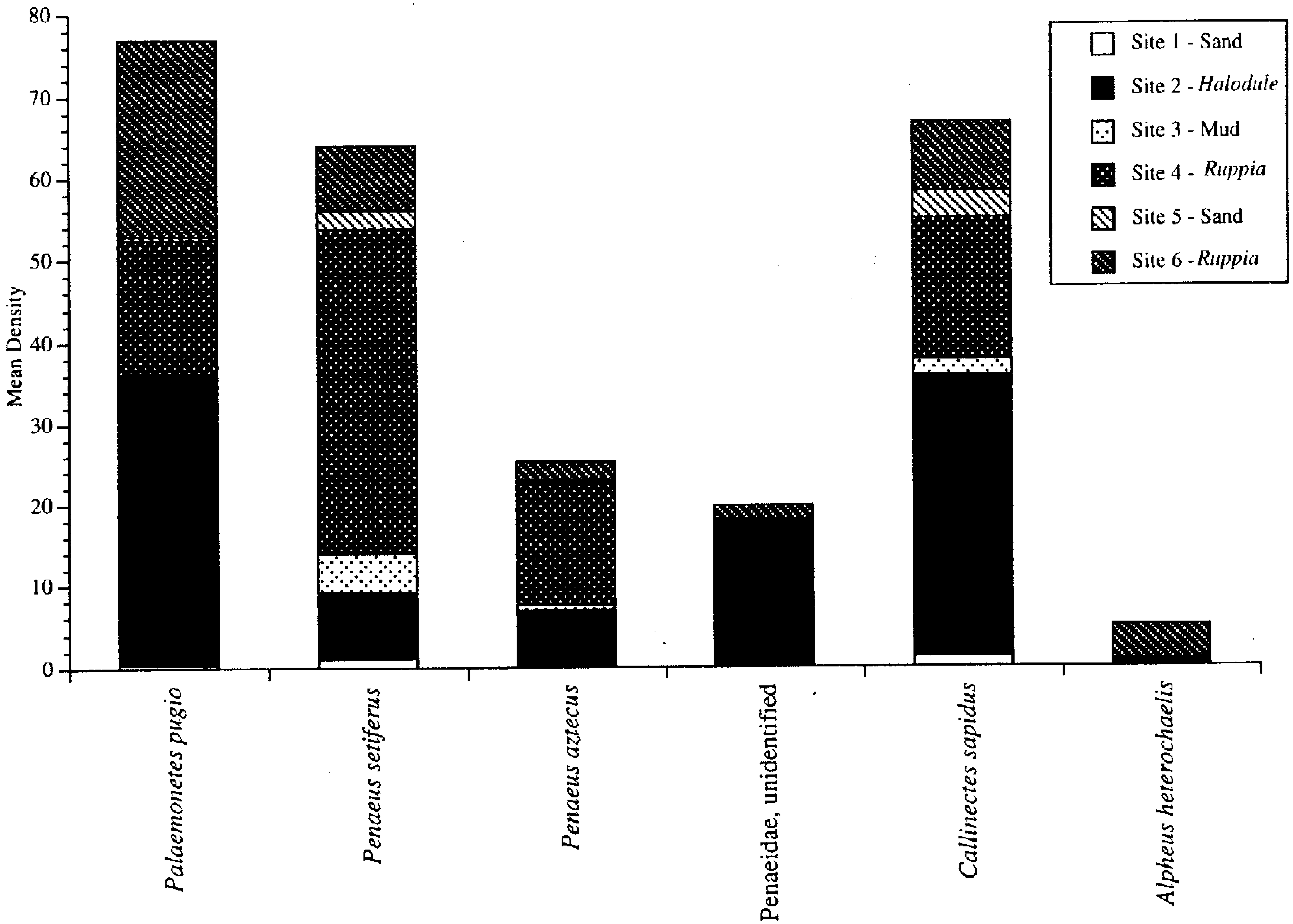


Figure 9. Decapod taxa with mean densities exceeding 0.5 individuals per m² collected in throw trap samples in fall 1993.

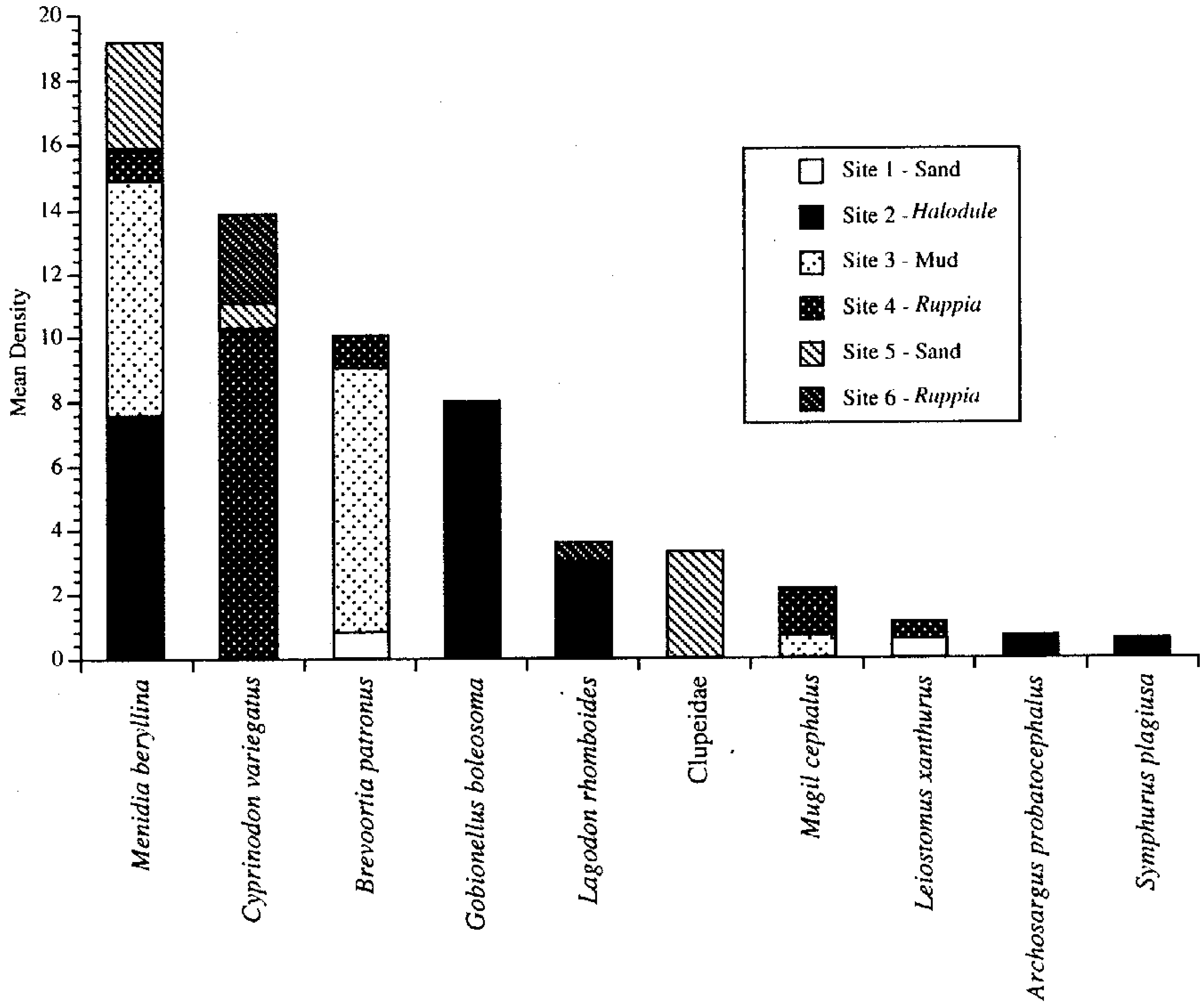


Figure 10. Fish taxa with mean densities exceeding 0.5 individuals per m^2 collected in throw trap samples in spring 1994.

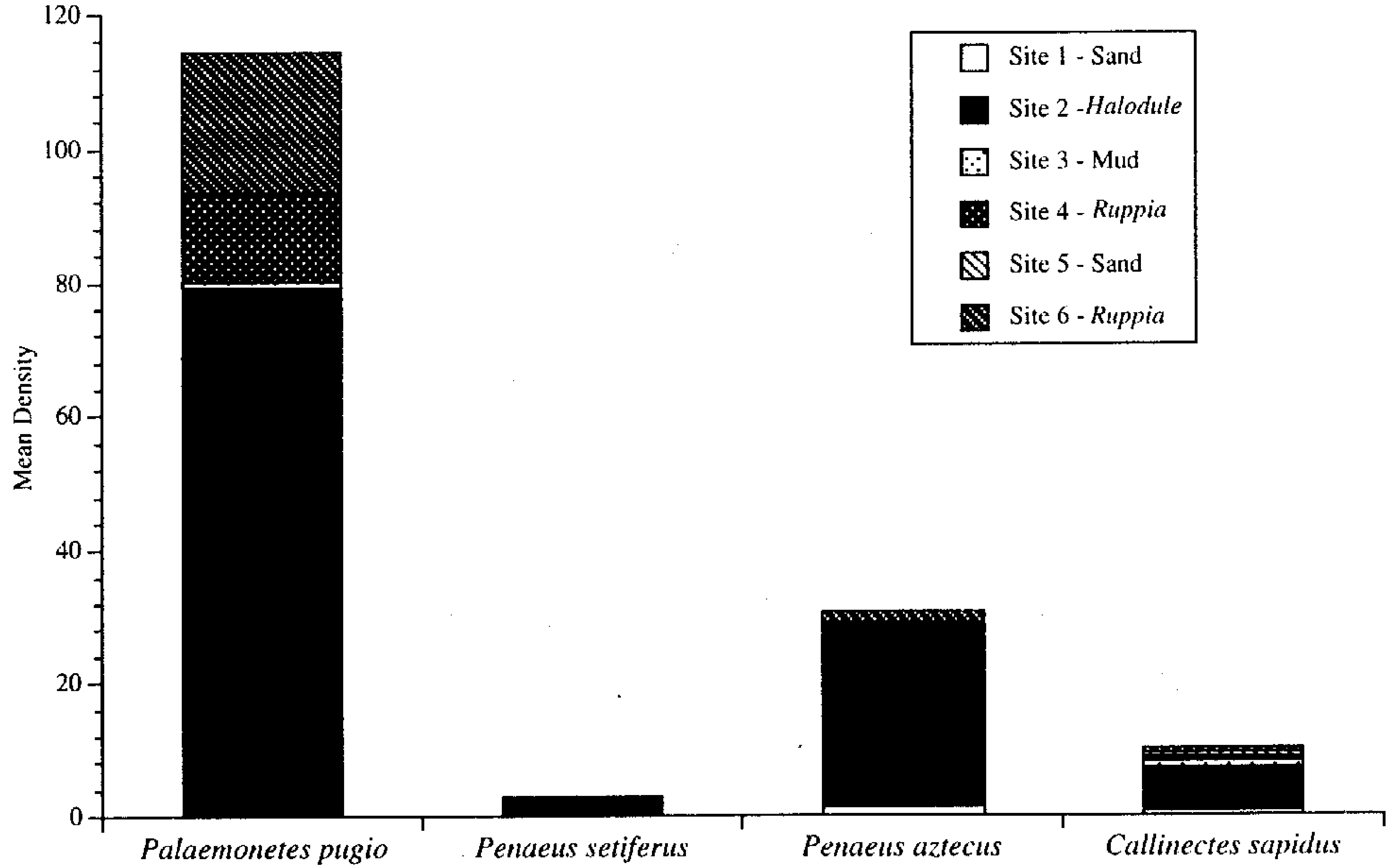


Figure 11. Decapod species with mean densities exceeding 0.5 individuals per m^2 collected in throw trap samples in spring 1994.

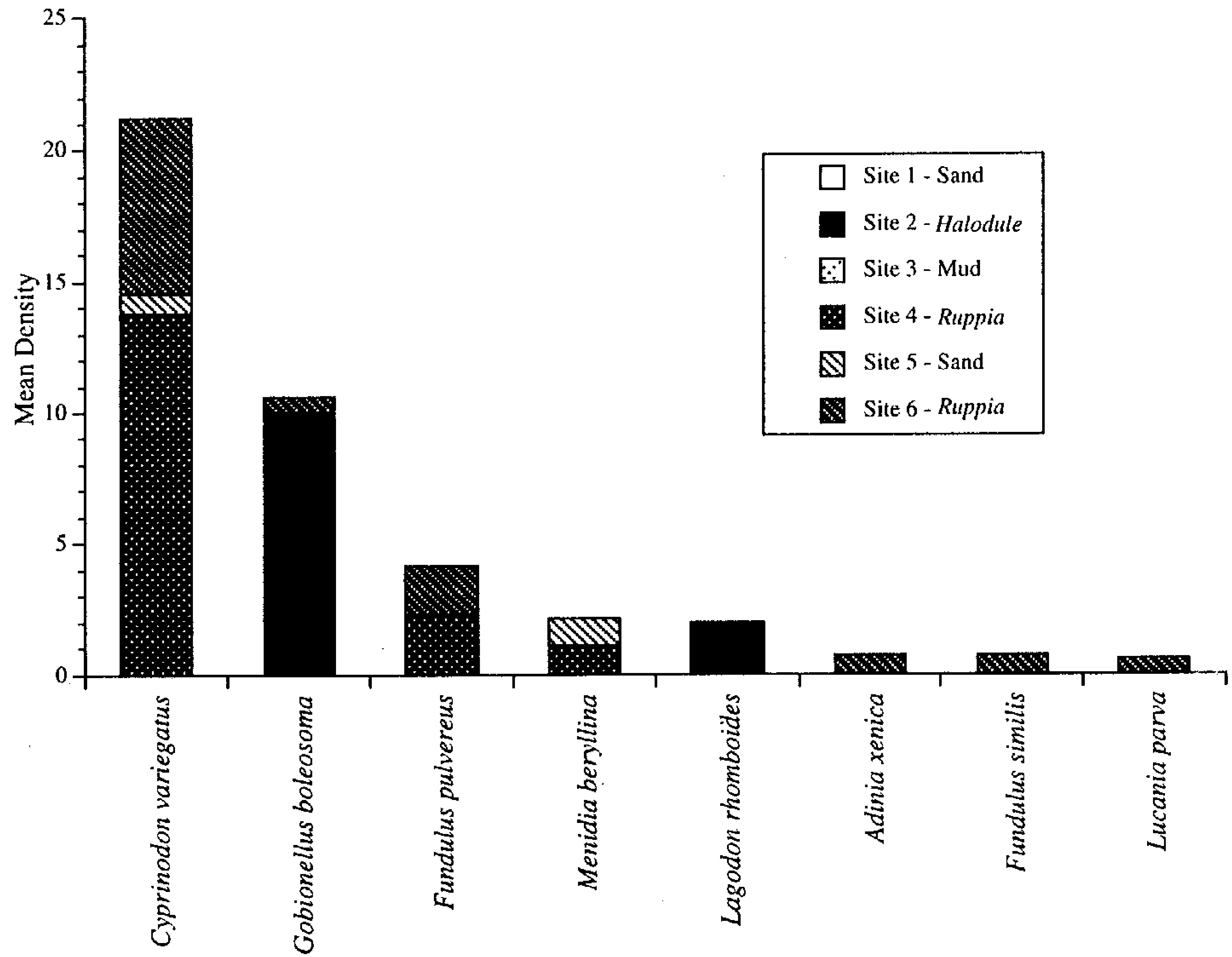


Figure 12. Fish species with mean densities exceeding 0.5 individuals per m^2 collected in throw trap samples in summer 1994.

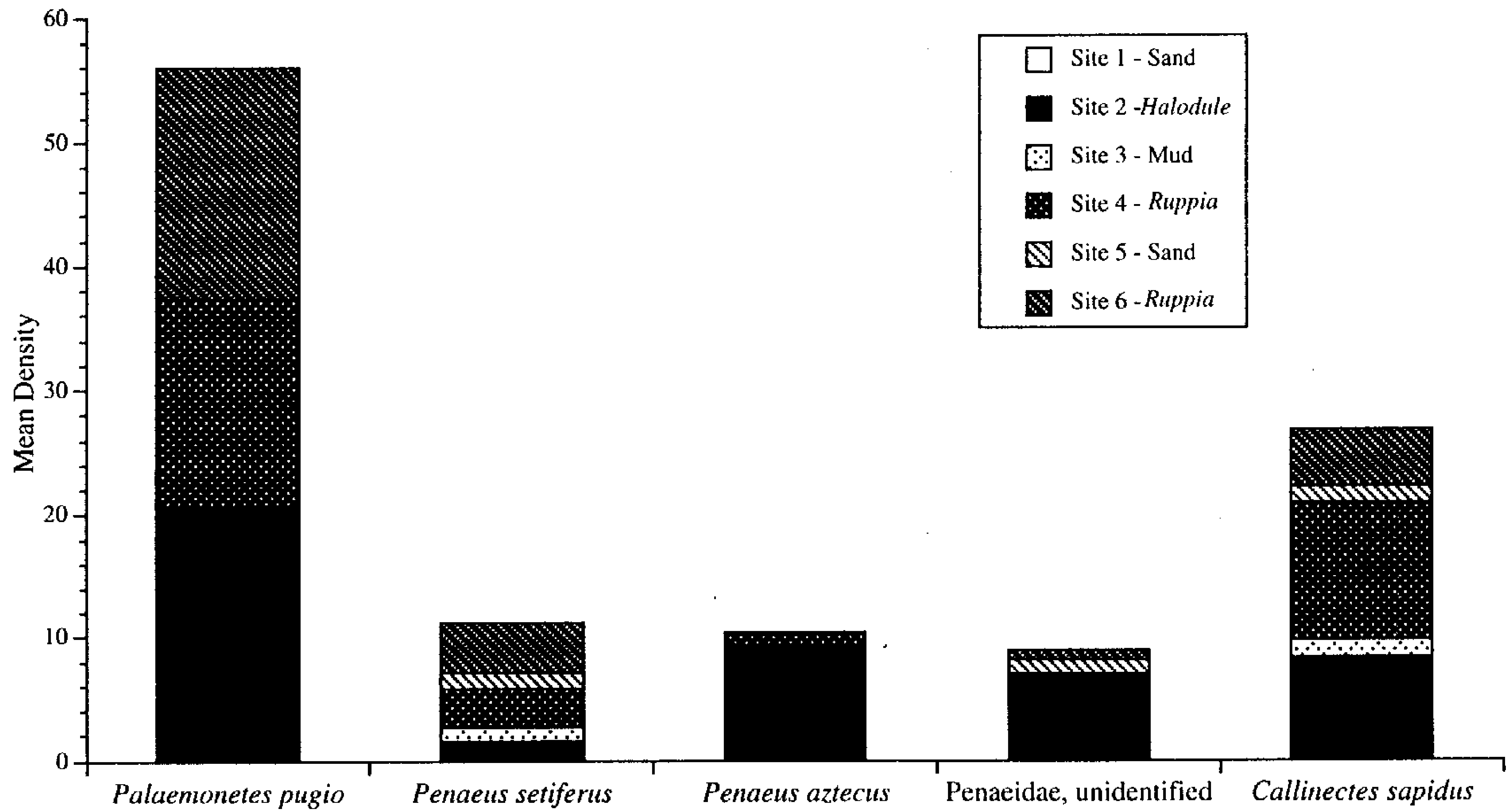


Figure 13. Decapod taxa with mean densities exceeding 0.5 individuals per m^2 collected in throw trap samples in summer 1994.

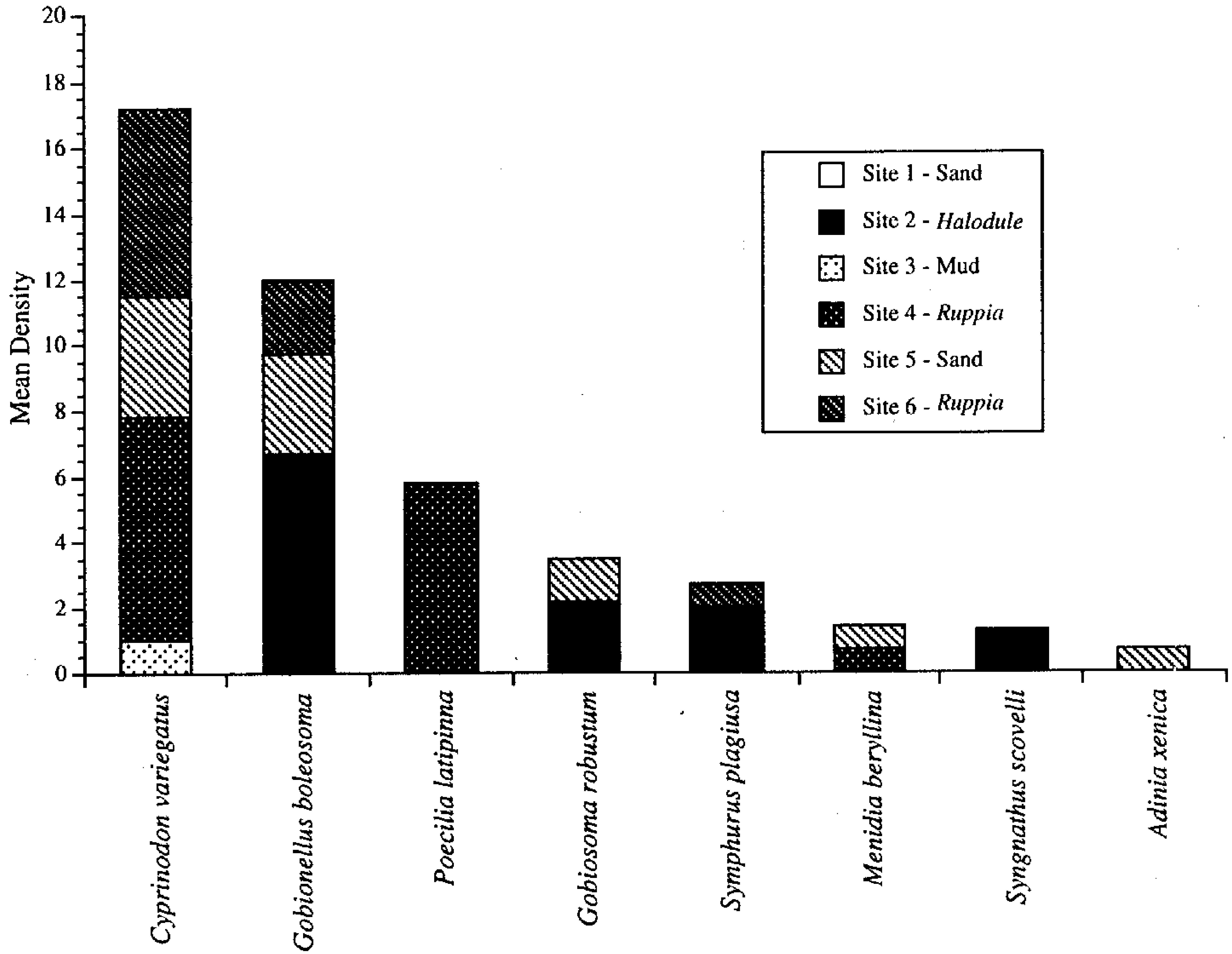


Figure 14. Fish species with mean densities exceeding 0.5 individuals per m^2 collected in throw trap samples in fall 1994.

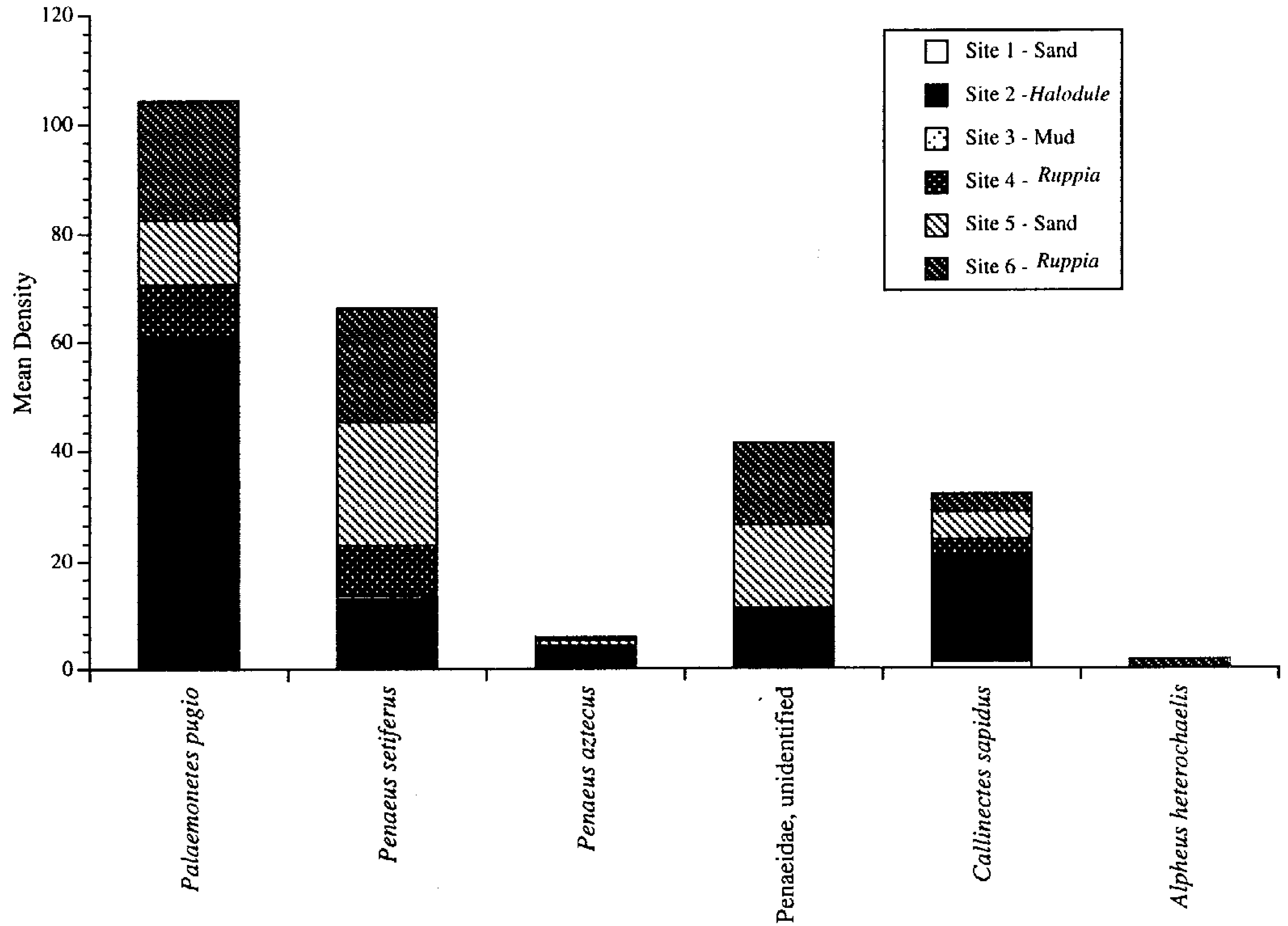


Figure 15. Decapod taxa with mean densities exceeding 0.5 individuals per m² collected in throw trap samples in fall 1994.

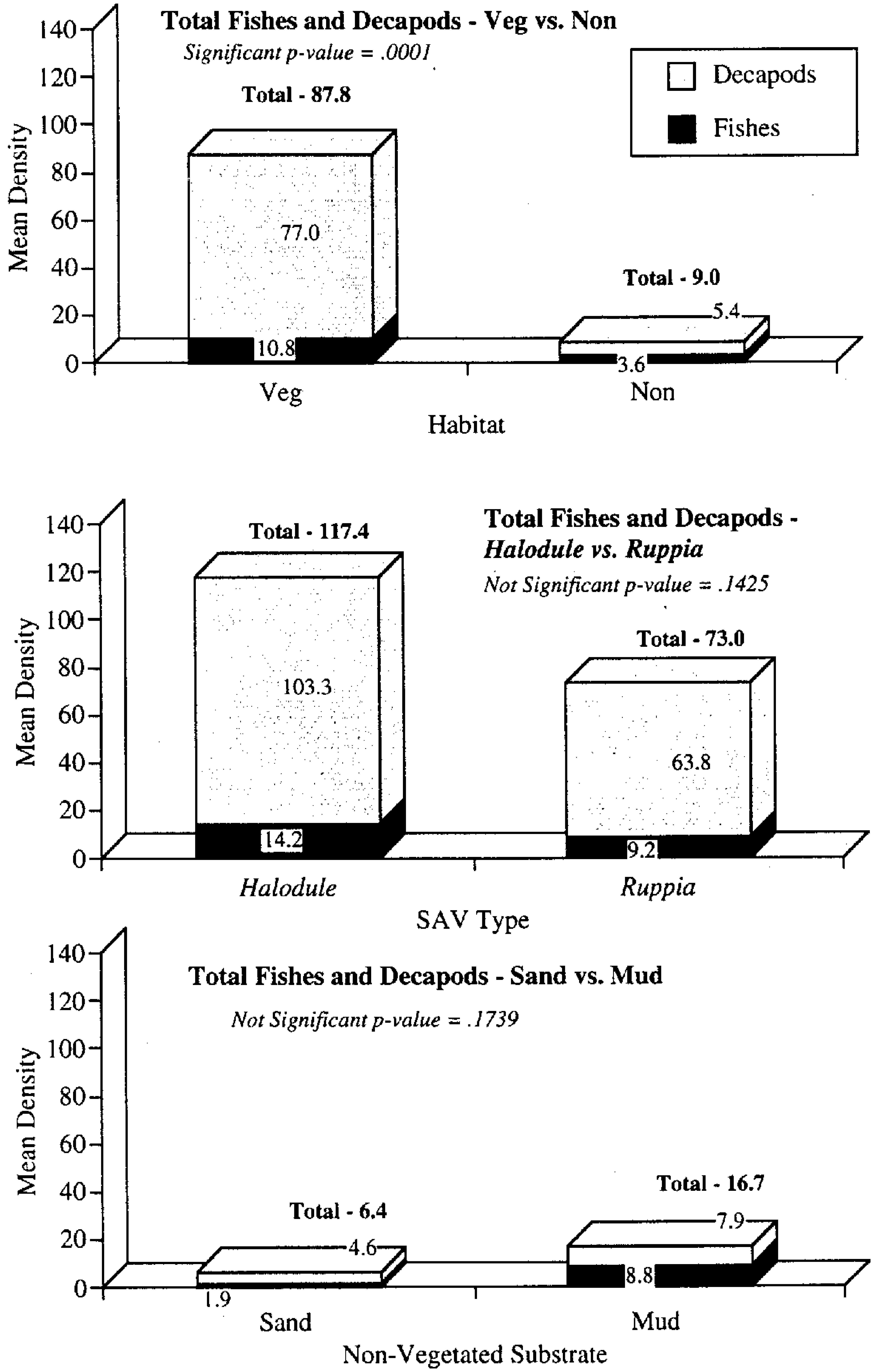
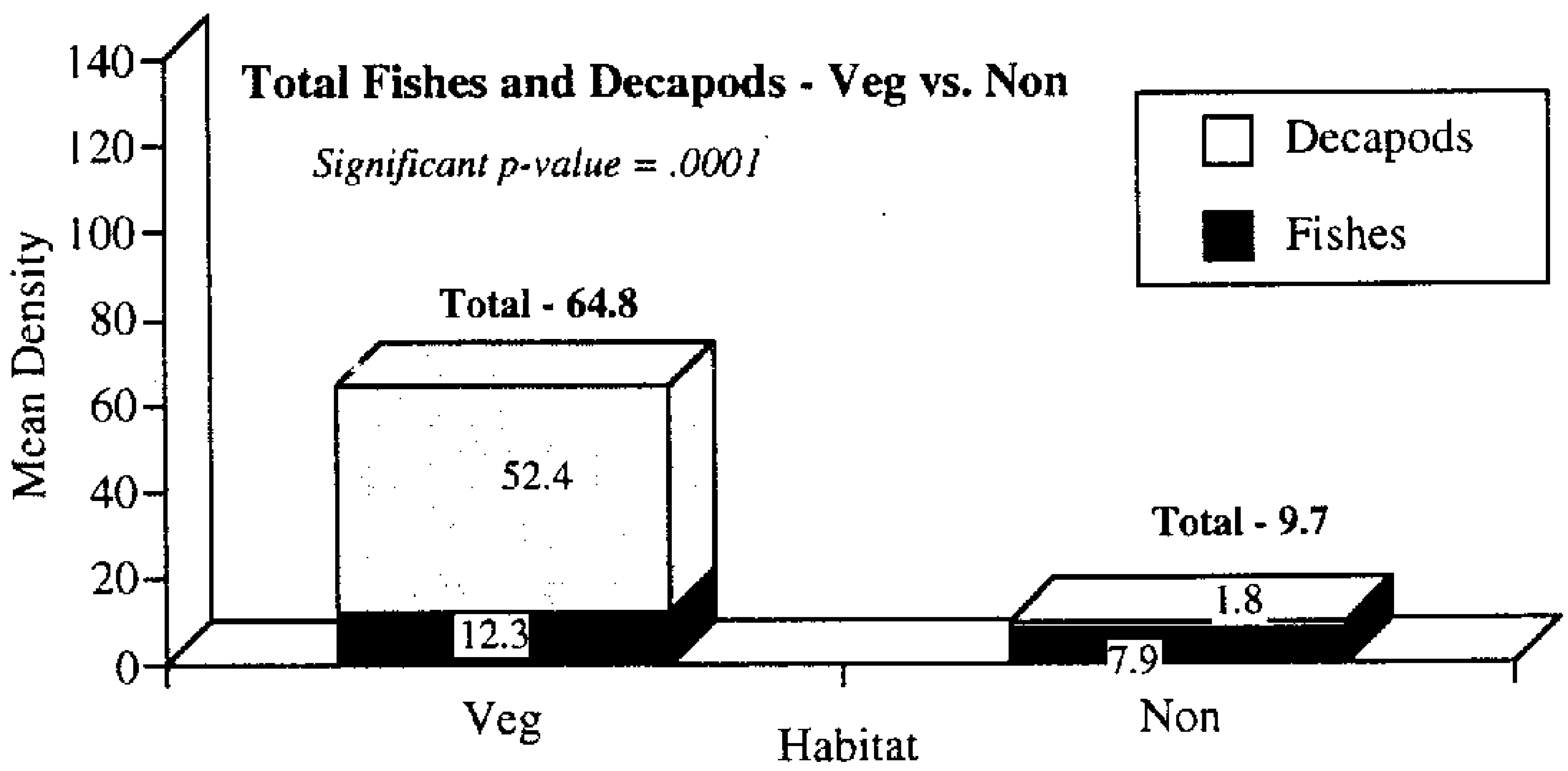
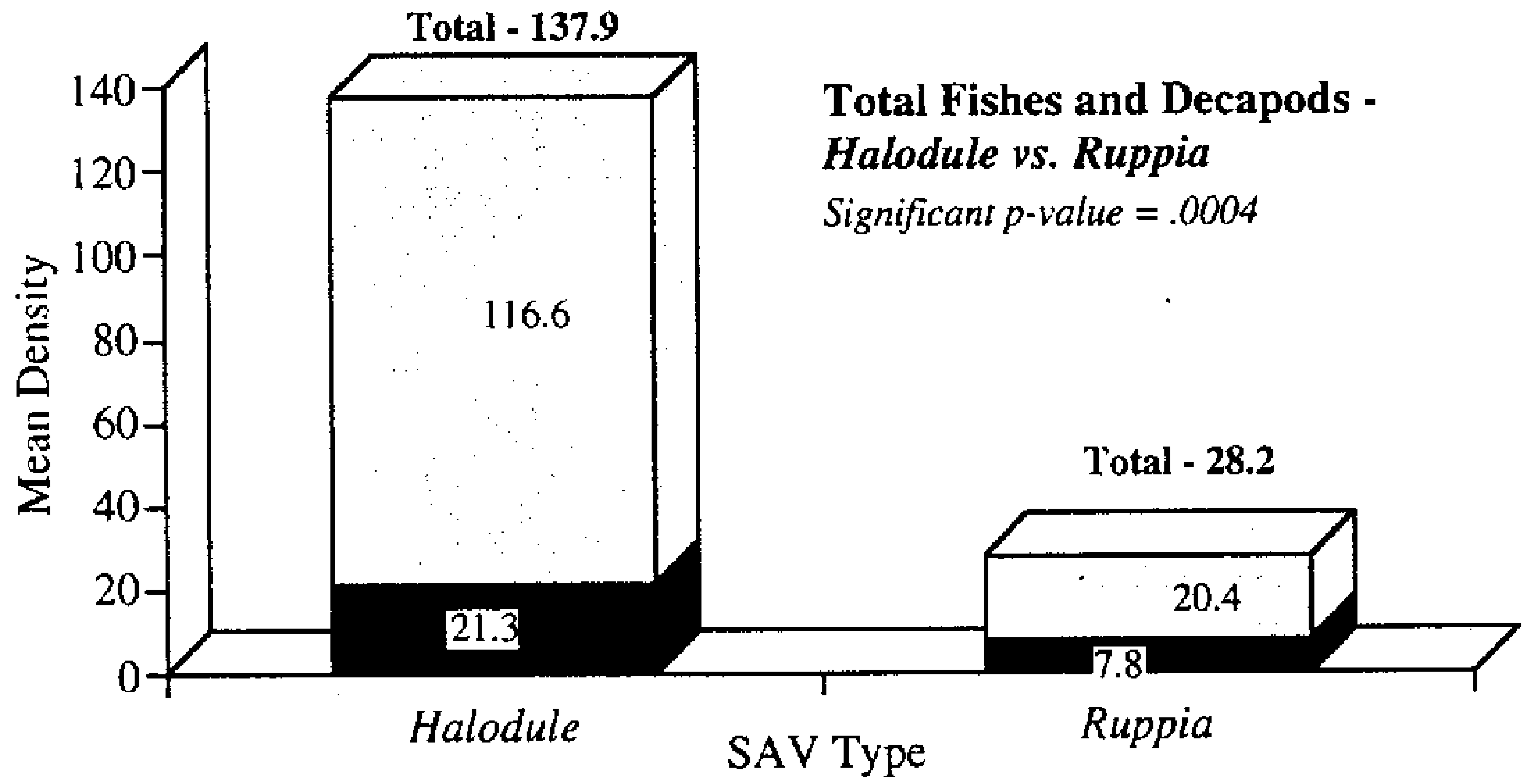


Figure 16. Mean densities (number per m^2) of total fishes and decapods by habitat, SAV type and non-vegetated substrate in fall 1993.





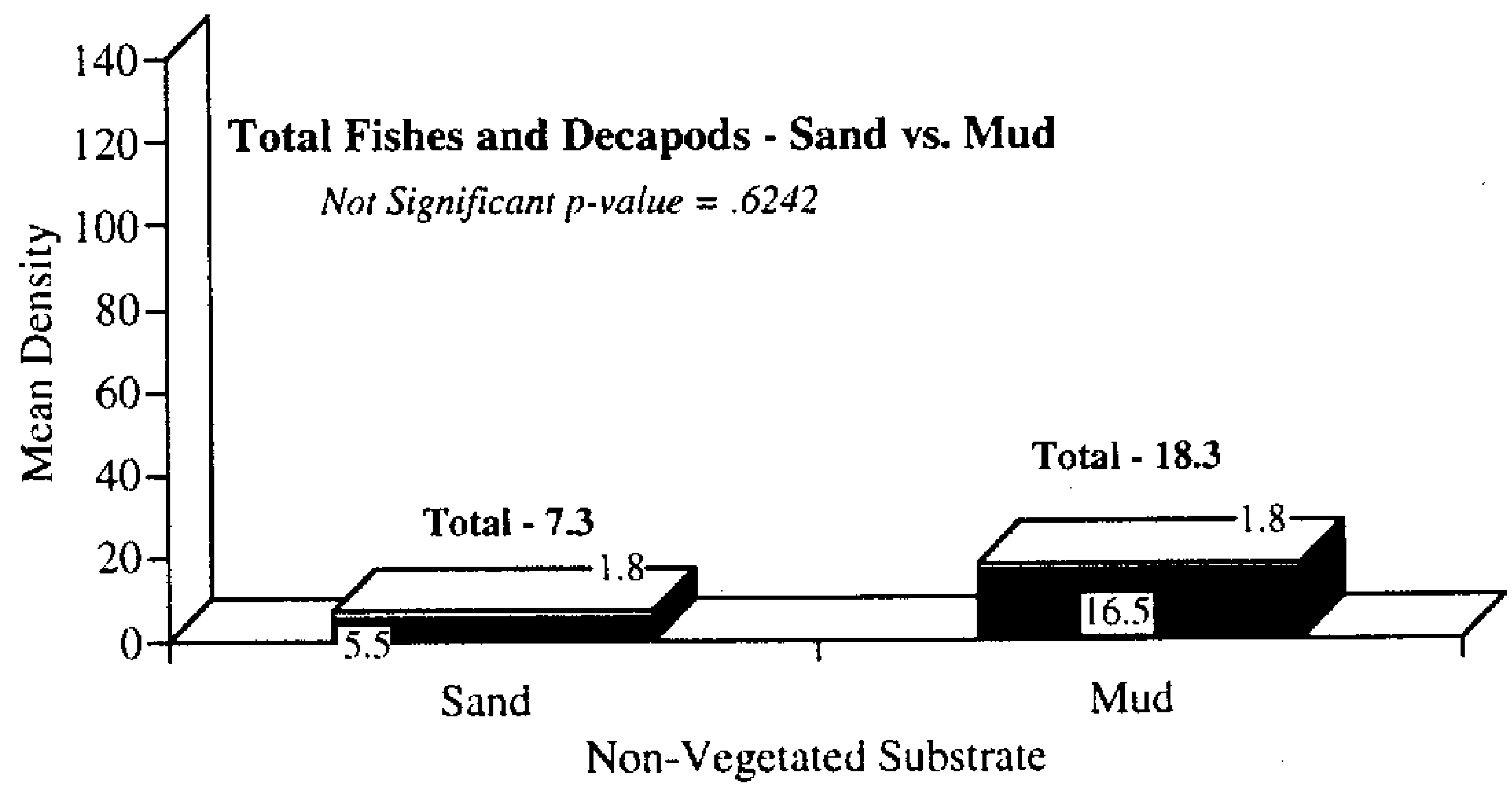


Figure 17. Mean densities (number per m^2) of total fishes and decapods by habitat, SAV type and non-vegetated substrate in spring 1994.

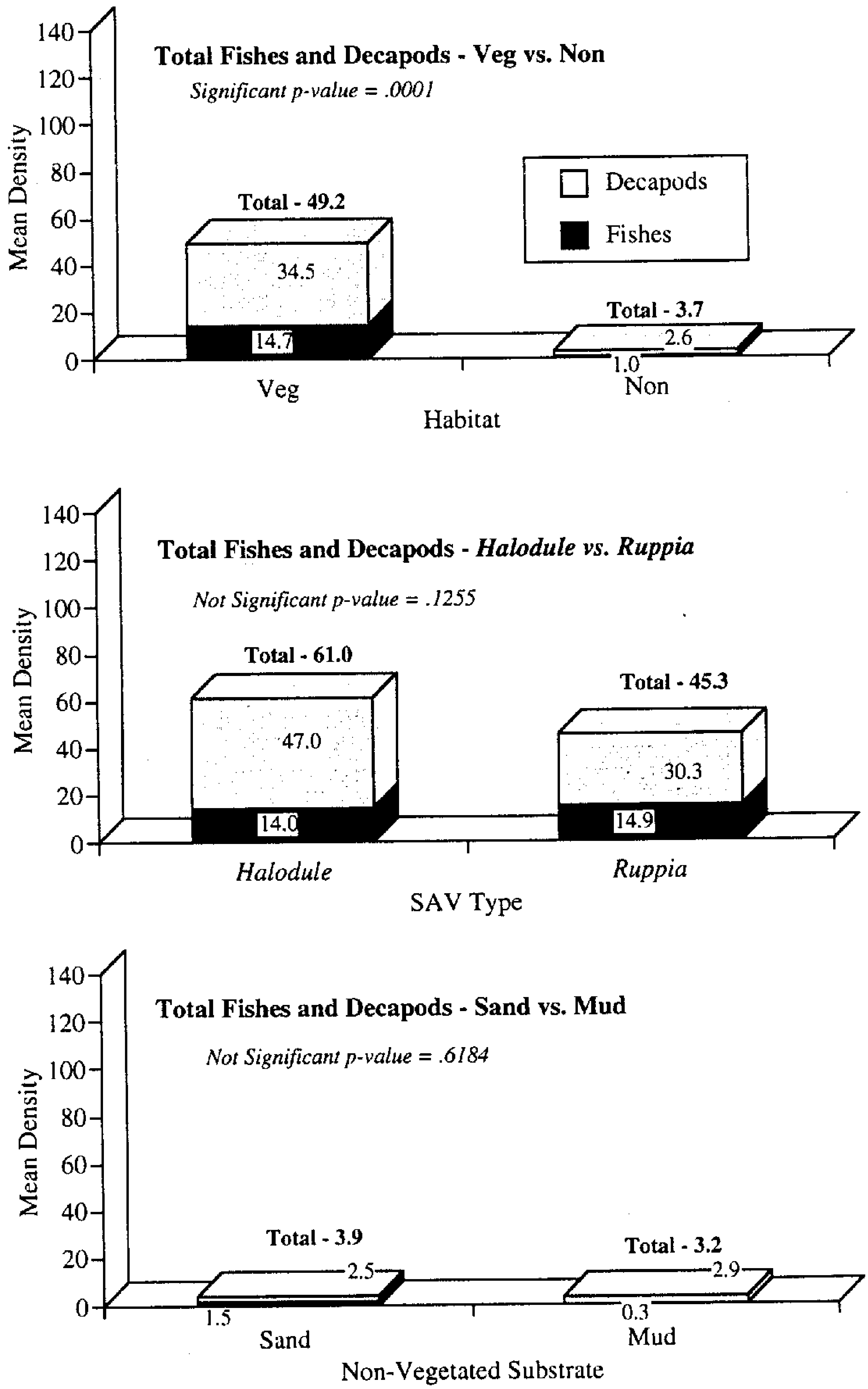


Figure 18. Mean densities (number per m^2) of total fishes and decapods by habitat, SAV type and non-vegetated substrate in summer 1994.

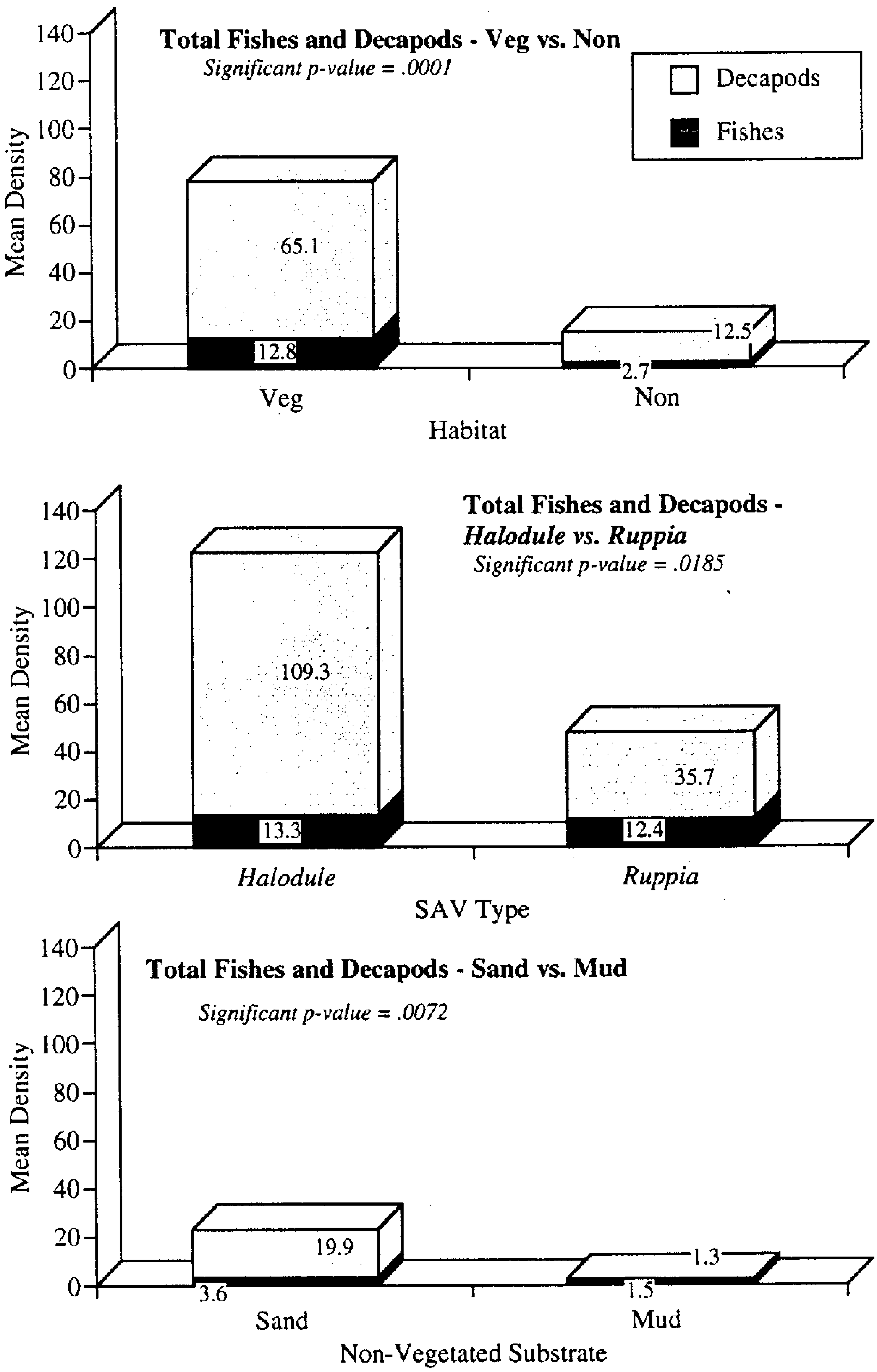


Figure 19. Mean densities (number per m^2) of total fishes and decapods by habitat, SAV type and non-vegetated substrate in fall 1994.

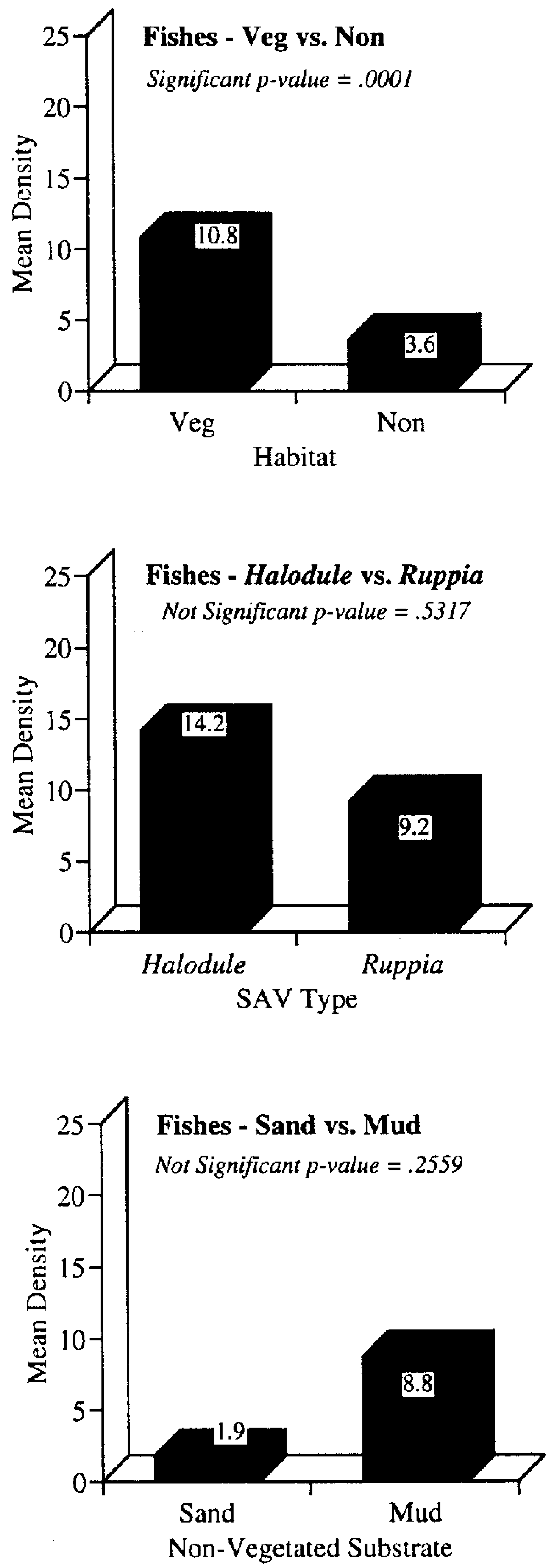


Figure 20. Mean densities (number per m^2) of fishes by habitat, SAV type and non-vegetated substrate in fall 1993.

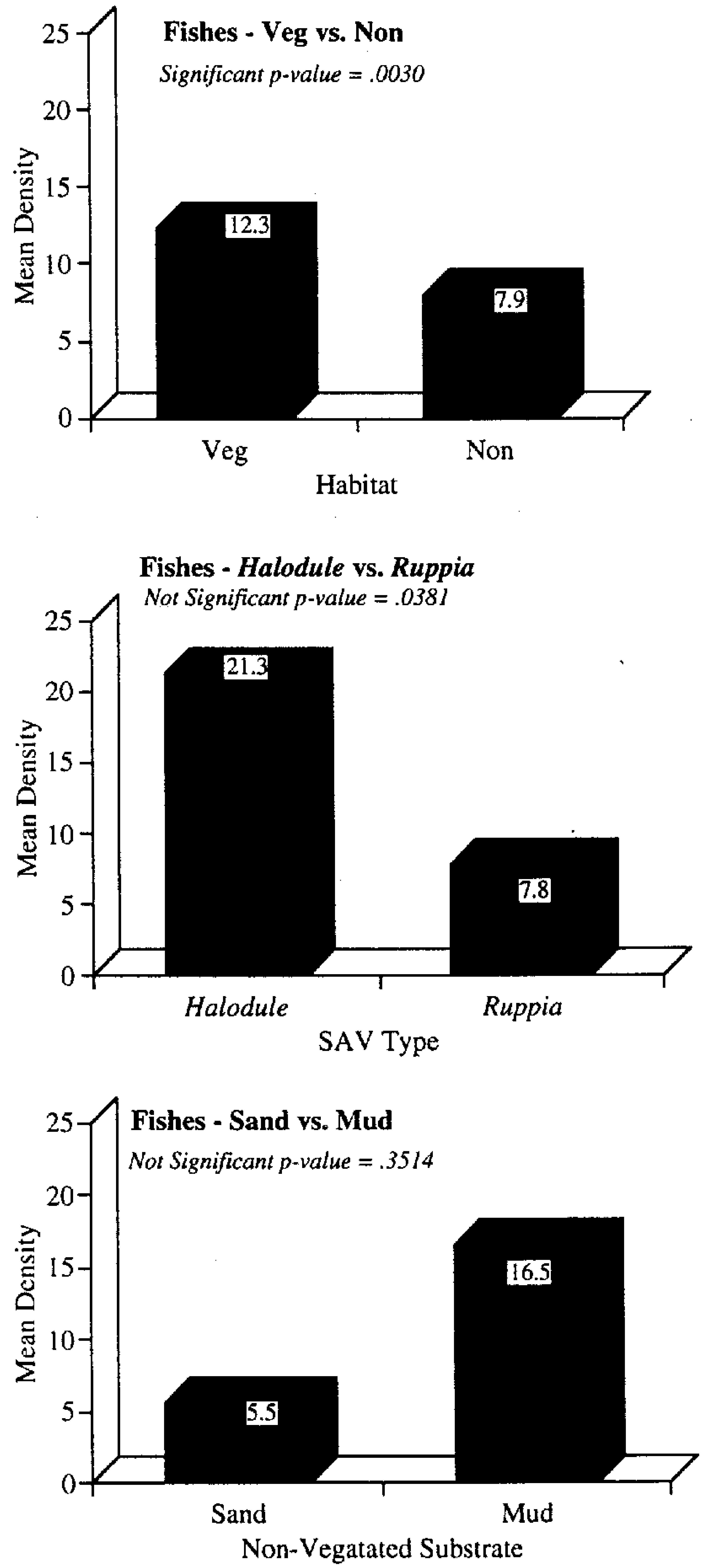


Figure 21. Mean densities (number per m^2) of fishes by habitat, SAV type and non-vegetated substrate in spring 1994.

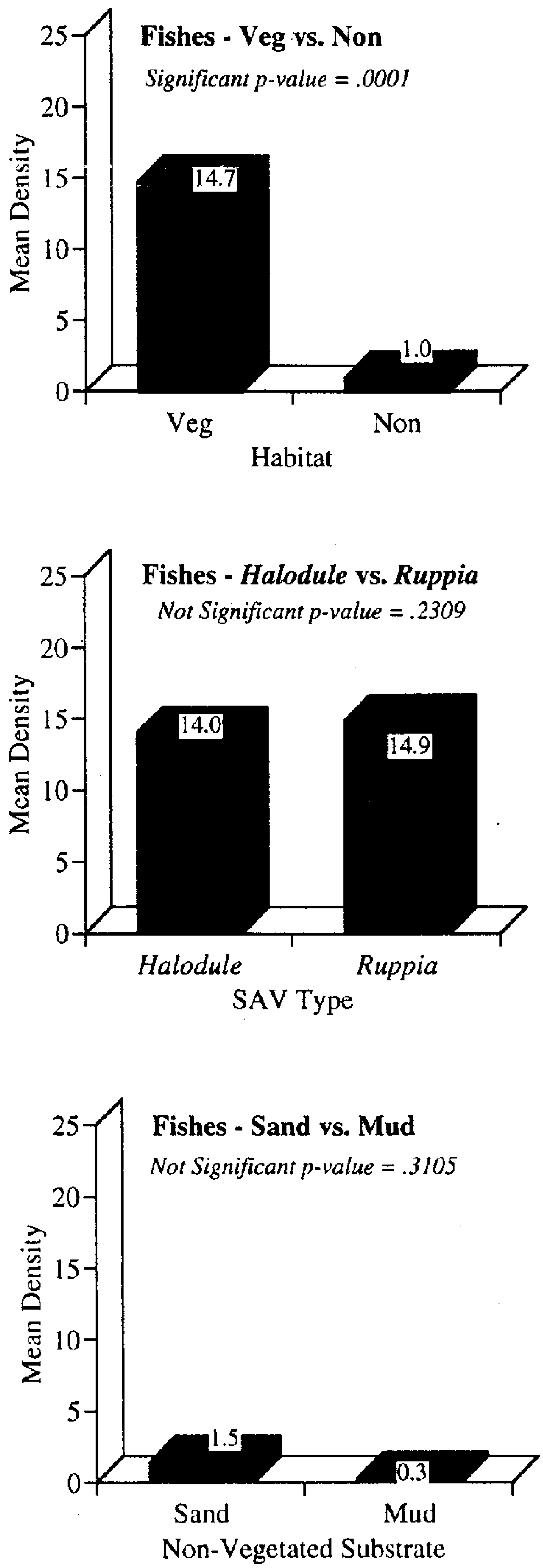


Figure 22. Mean densities (number per m^2) of fishes by habitat, SAV type and non-vegetated substrate in summer 1994.

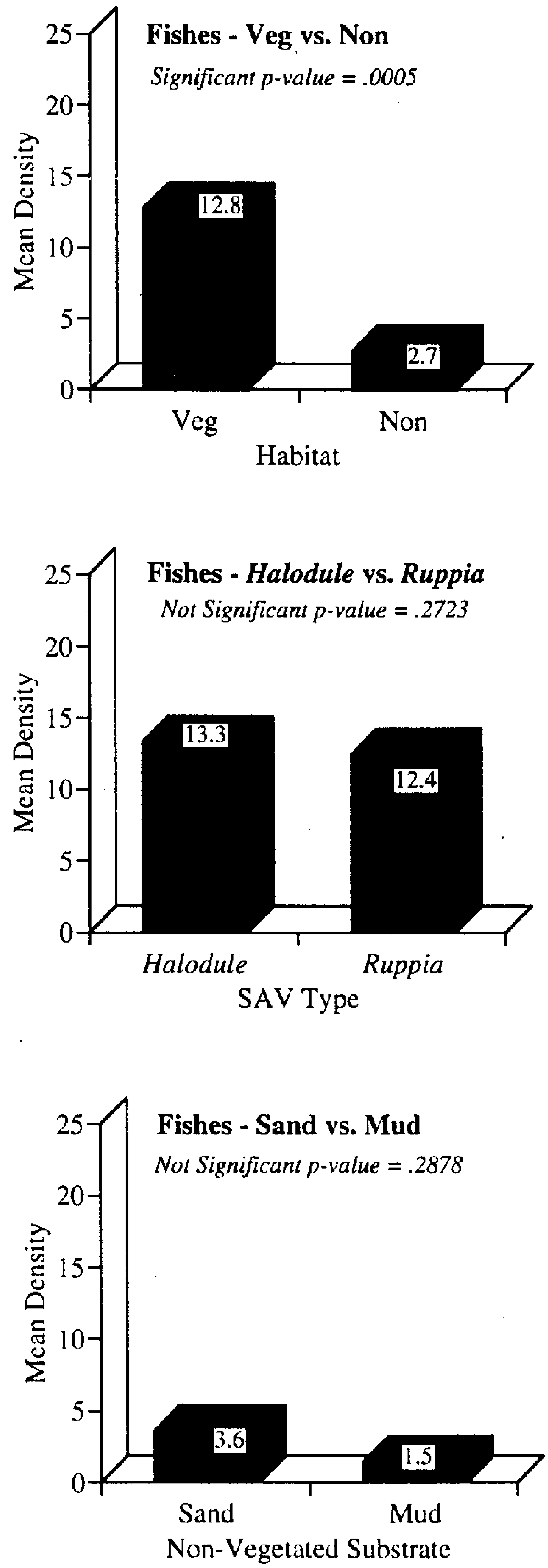


Figure 23. Mean densities (number per m^2) of fishes by habitat, SAV type and non-vegetated substrate in fall 1994.

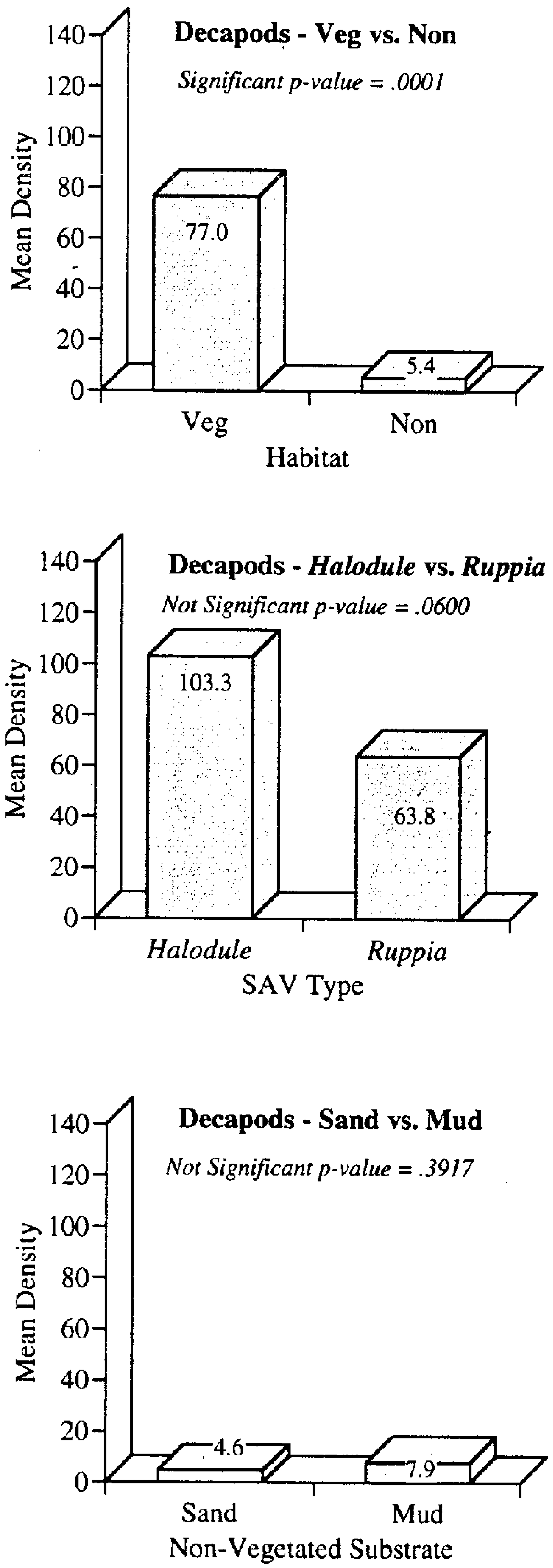


Figure 24. Mean densities (number per m^2) of decapods by habitat, SAV type and non-vegetated substrate in fall 1993.

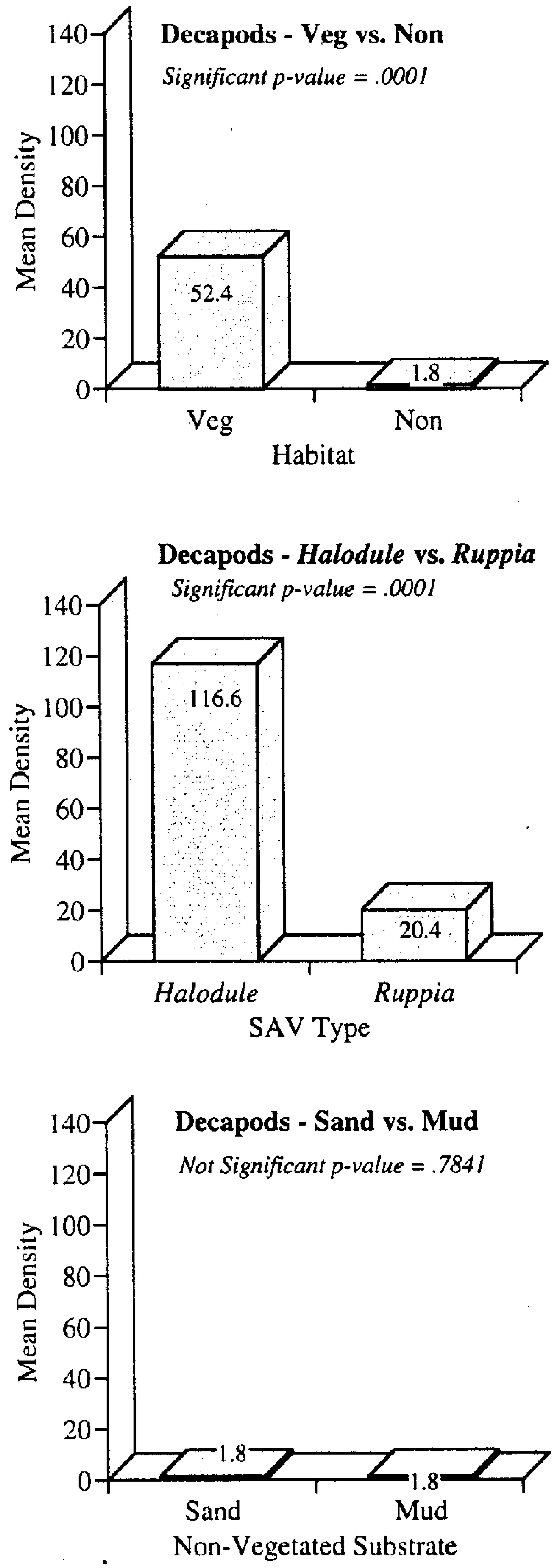


Figure 25. Mean densities (number per m^2) of decapods by habitat, SAV type and non-vegetated substrate in spring 1994.

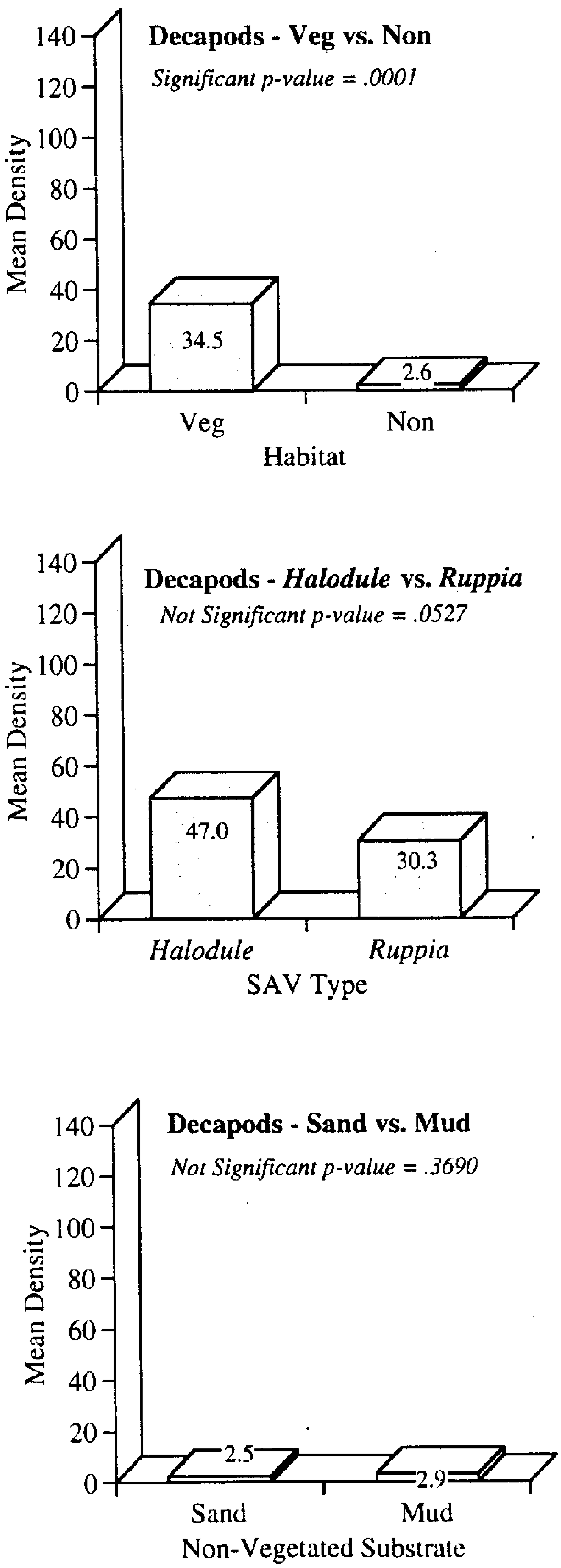


Figure 26. Mean densities (number per m^2) of decapods by habitat, SAV type and non-vegetated substrate in summer 1994.

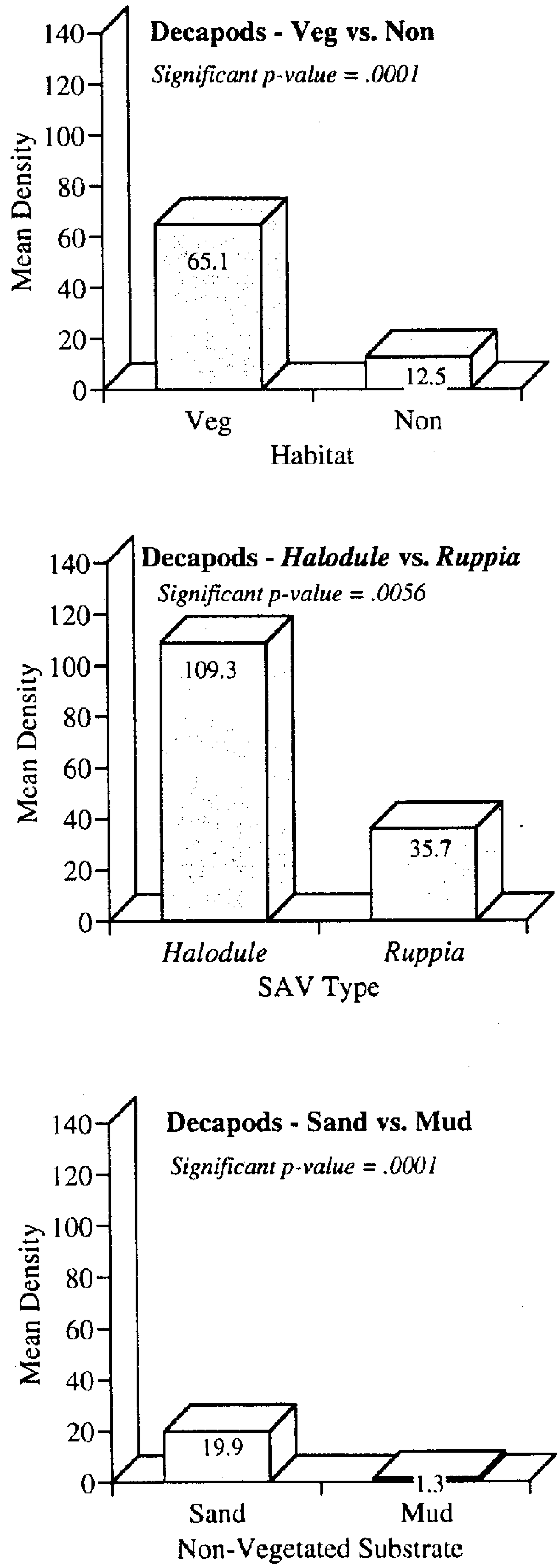


Figure 27. Mean densities (number per m^2) of decapods by habitat, SAV type and non-vegetated substrate in fall 1994.

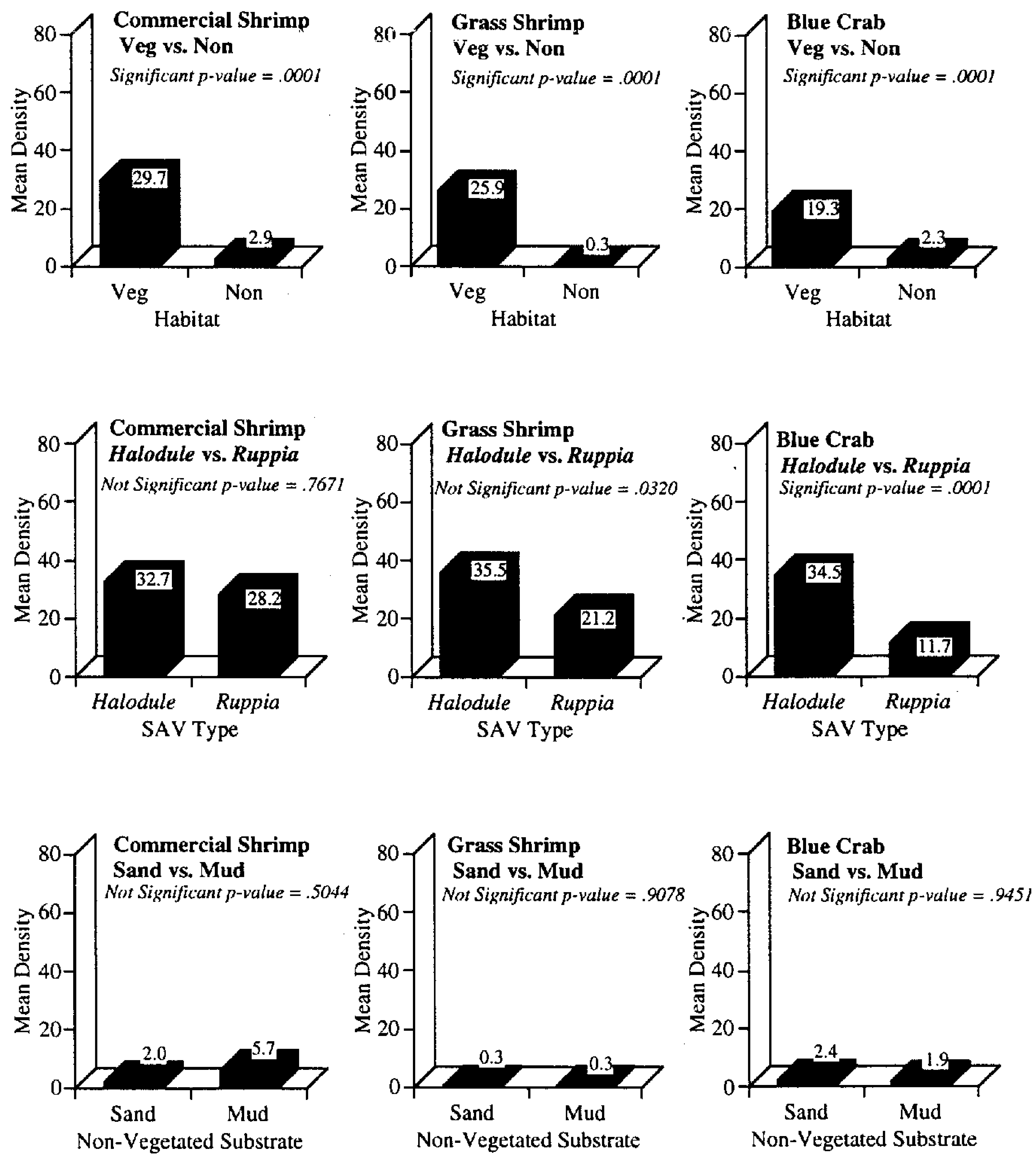


Figure 28. Mean densities (number per m^2) of abundant and commercially important decapods by habitat, SAV type and non-vegetated substrate in fall 1993.

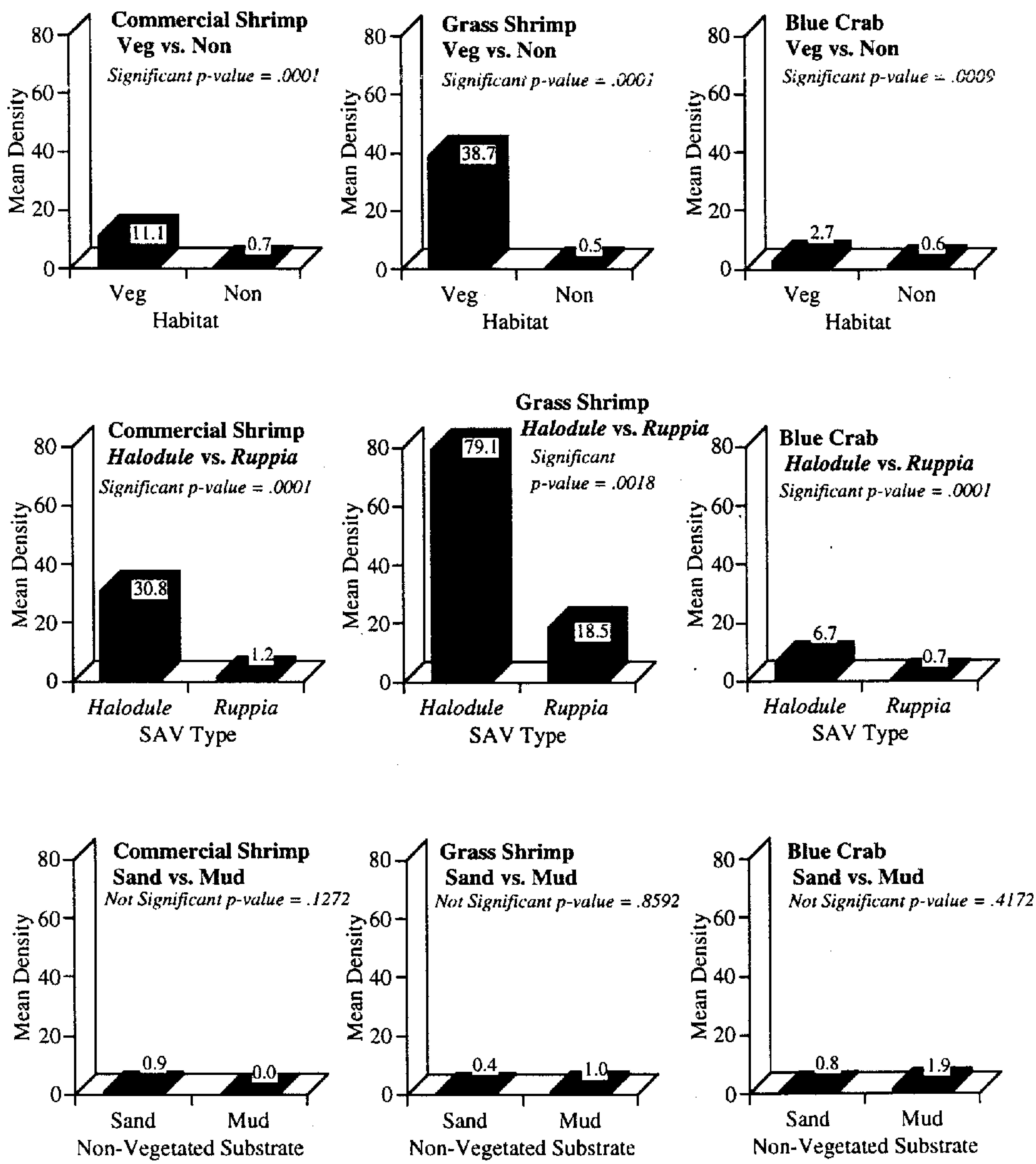


Figure 29. Mean densities (number per m^2) of abundant and commercially important decapods by habitat, SAV type and non-vegetated substrate in spring 1994.

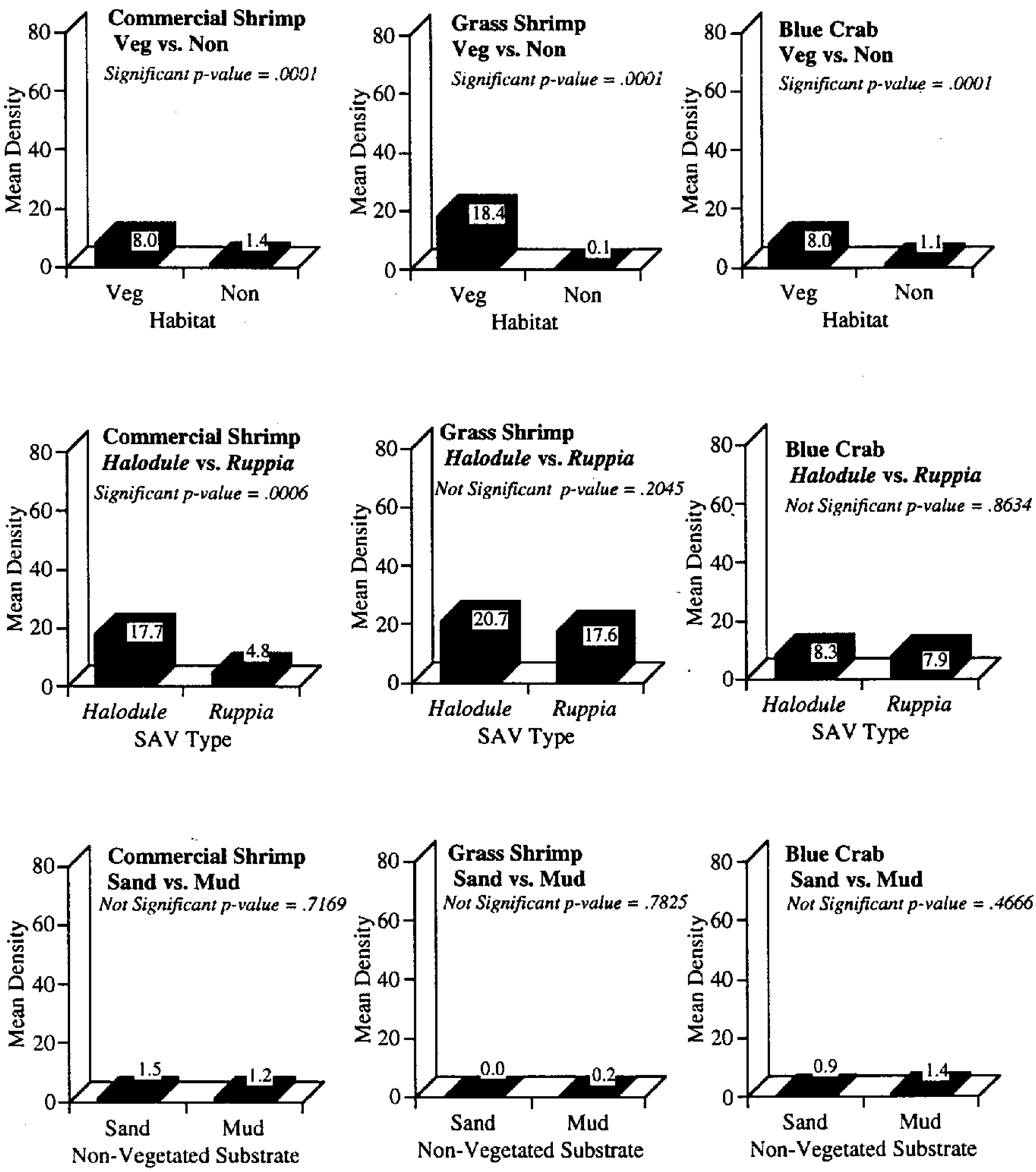


Figure 30. Mean densities (number per m^2) of abundant and commercially important decapods by habitat, SAV type and non-vegetated substrate in summer 1994.

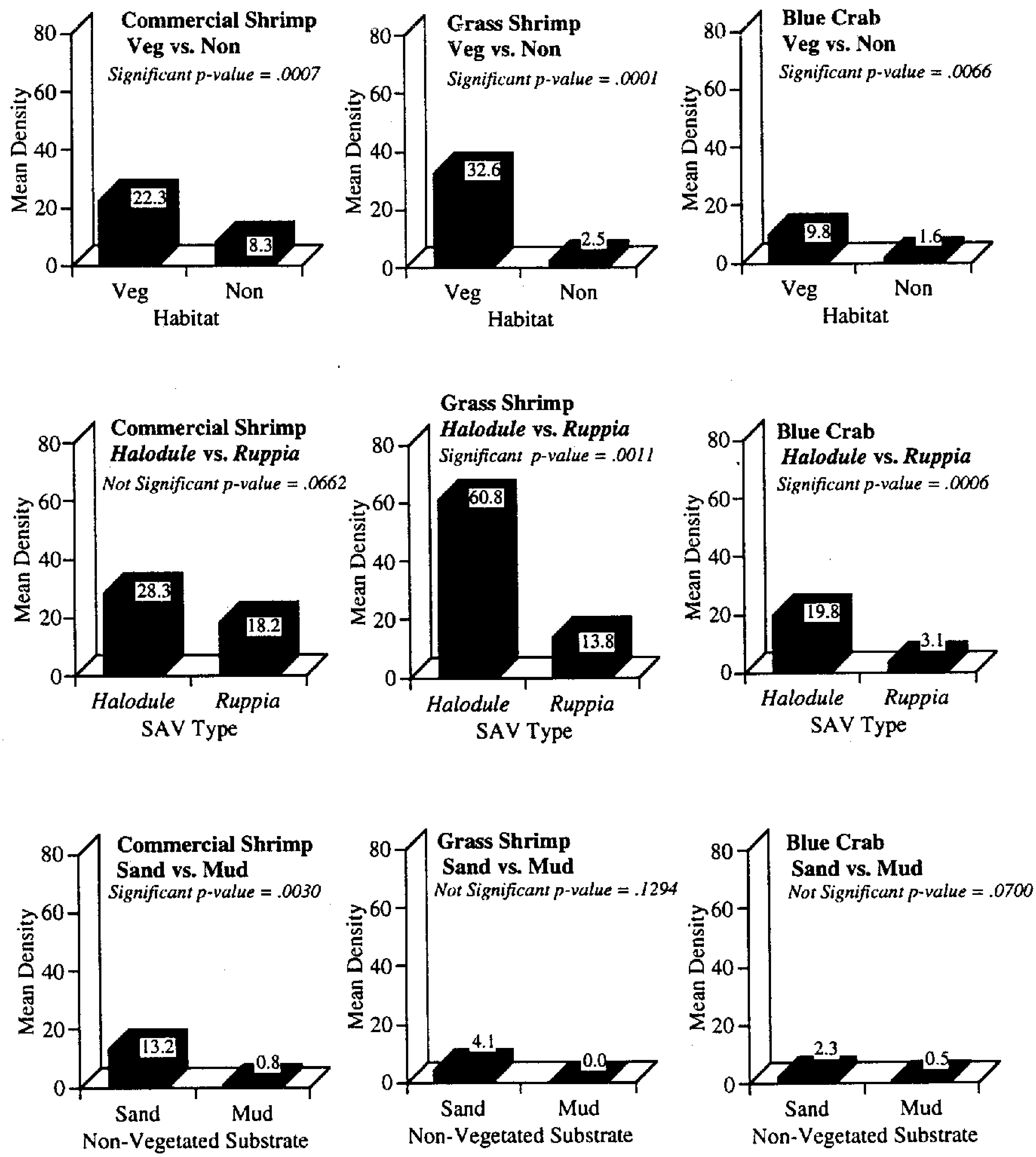


Figure 31. Mean densities (number per m^2) of abundant and commercially important decapods by habitat, SAV type and non-vegetated substrate in fall 1994.

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NUS Analytical Laboratory. 1983-1984. Clear Lake, Texas. Junior Chemist.

Selected Scientific Presentations:

Gulf of Mexico Fishery Management Council, July 1995, April & May 1996, Florida
MARFIN Conferences, 1994 - Mississippi, & 1995 - Florida
South Atlantic Fishery Management Council, August 1995, South Carolina
Bycatch Reduction Device Gear Review Panel, May 1995, Florida
NMFS Observer Working Group, January 1995, Washington D.C.
International Workshop on Tropical Groupers & Snappers, 1993, Campeche, Mexico
NMFS National Stock Assessment Workshop, July 1993, Massachusetts

Selected Publications and Reports:

Nance, J. M. and E. Scott-Denton. In press. Bycatch in the Gulf of Mexico shrimp fishery. Proceedings of the 2nd World Fisheries Congress.

Scott-Denton, E. and J. Nance. 1997. Shrimp trawl bycatch research in the US Gulf of Mexico and Southeastern Atlantic. Pages 369-371 *in* F. Arrequin-Sanchez, J. L. Munro, M. C. Balgos and D. Pauly eds. Biology, fisheries and culture of tropical groupers and snappers. ICLARM Conf. Proc. 48.

Renaud, M. L., J. M. Nance, E. Scott-Denton, and G. R. Gitschlag. 1997. Incidental capture of sea turtles in shrimp trawls. Chelonian Conservation and Biology 2: 425-427.

Scott-Denton, E. 1997. Forecast of the 1997 offshore brown shrimp season-from the Mississippi River to the US-Mexico Border. Report-GMFMC. 7 pp.

Scott-Denton, E. and D. Harper. 1995. Characterization of the reef fish fishery of the eastern Gulf of Mexico. Report to the GMFMC, July 1995, Key West, Florida.

Baxter, K. N., C. H. Furr., Jr., and E. Scott. 1988. The commercial bait shrimp fishery in Galveston Bay, Texas, 1959 -87. Mar. Fish. Rev. 50: 20-28.

Honors, Awards and Other Activities:

Outstanding Work Performance NMFS - 1986, 1989, 1991, 1993-97
Washington D.C. Programs- New Leader (1995-96); Advanced Studies - 1997-99
National Observer Working Group, Washington D.C. - 1997
Best Publication 1988 in Marine Fisheries Review
Unit Citation for Transborder Shrimp Project - 1985
Federal Women's Program Manager Council Houston/Galveston Area, 1983-97